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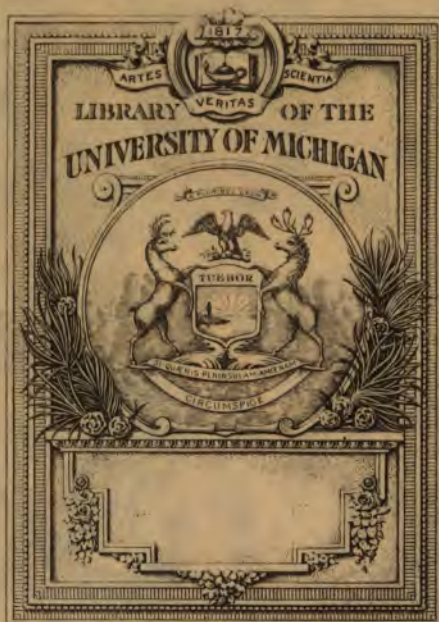
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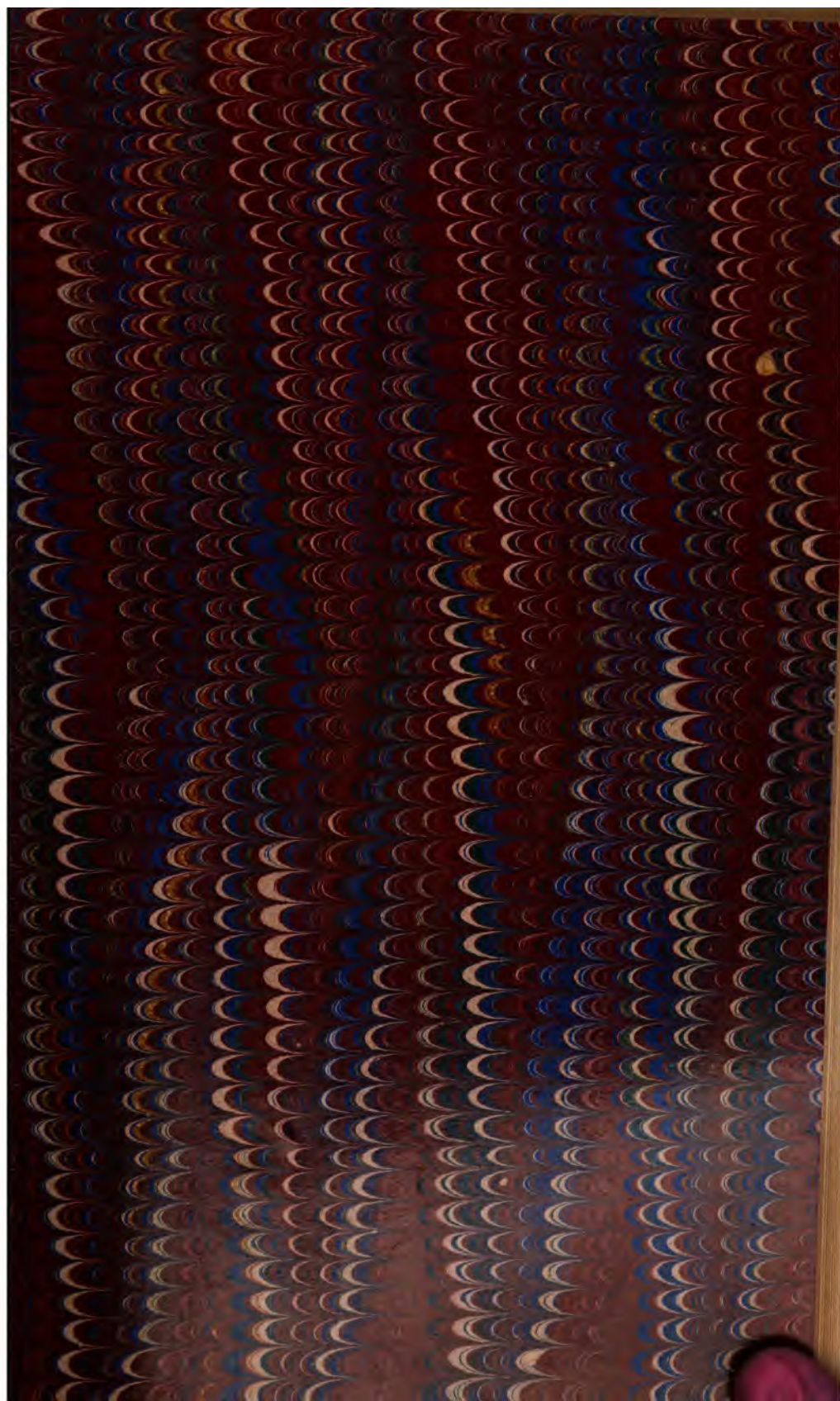
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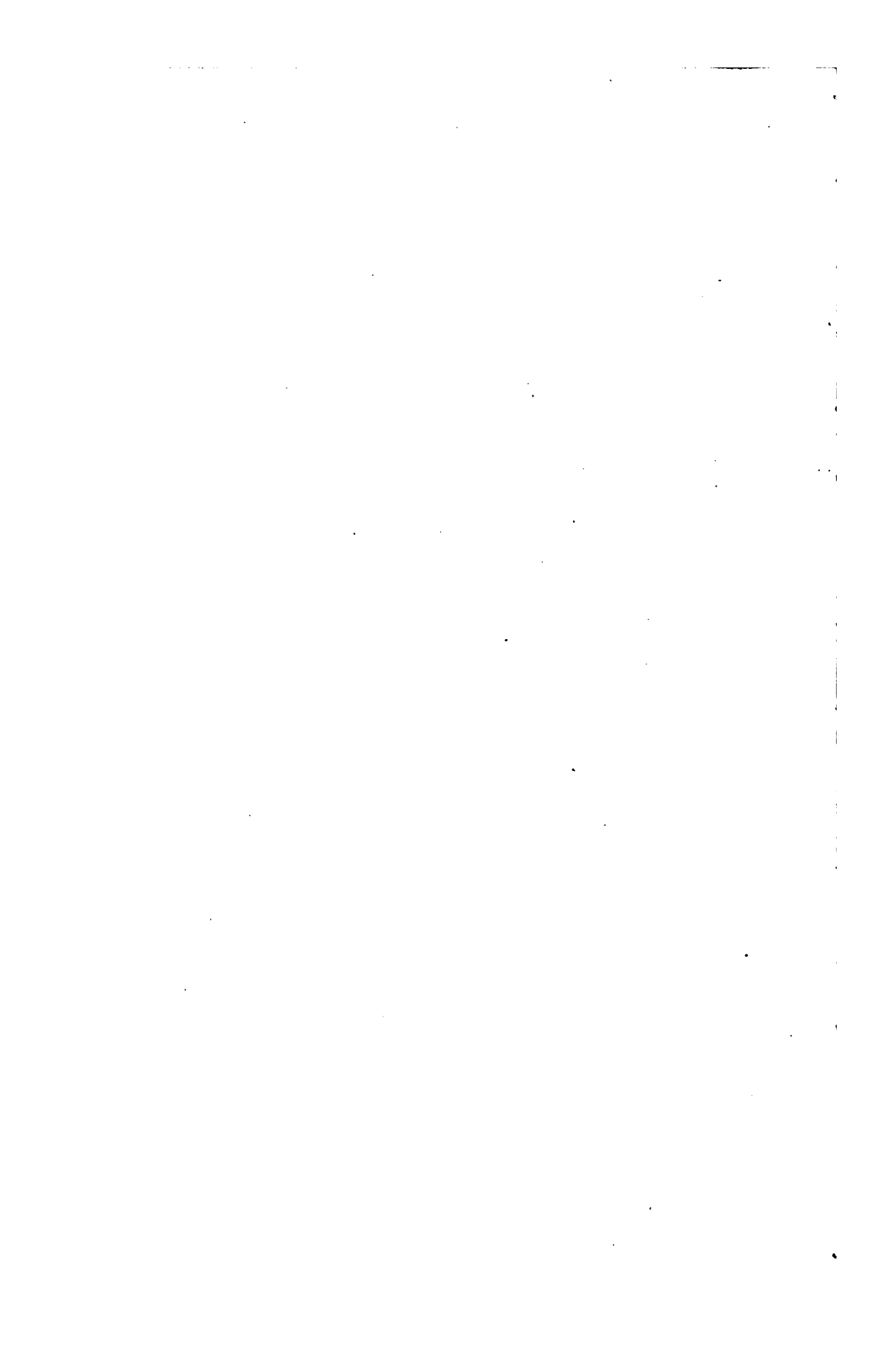
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A TREATISE ON
COAL MINING

TABLES AND FORMULAS

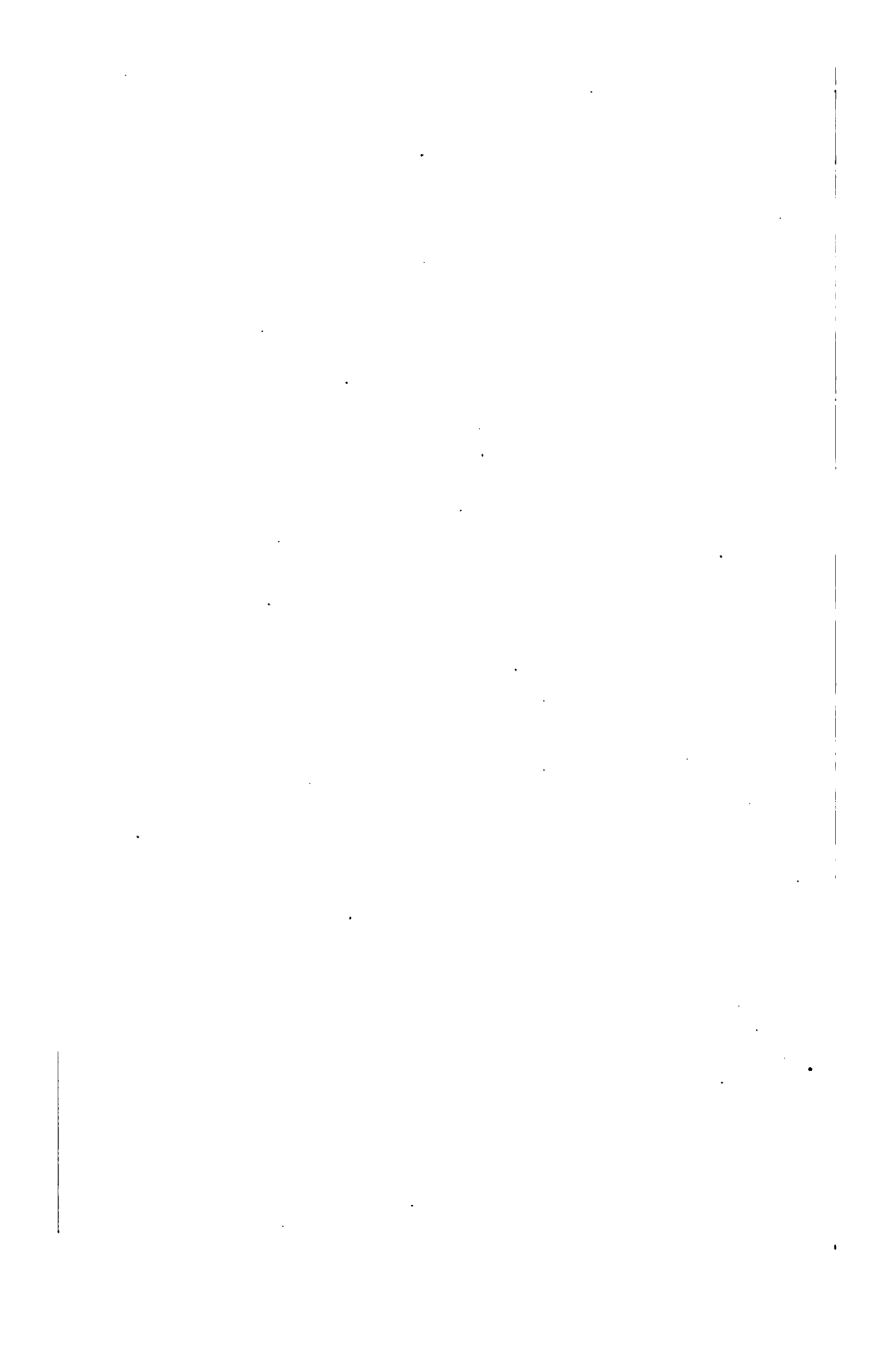






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Raymond Davis Borden.



A TREATISE
ON
COAL MINING

PREPARED FOR STUDENTS OF
THE INTERNATIONAL CORRESPONDENCE SCHOOLS
= SCRANTON, PA.

Volume V

TABLES AND FORMULAS

Second Edition

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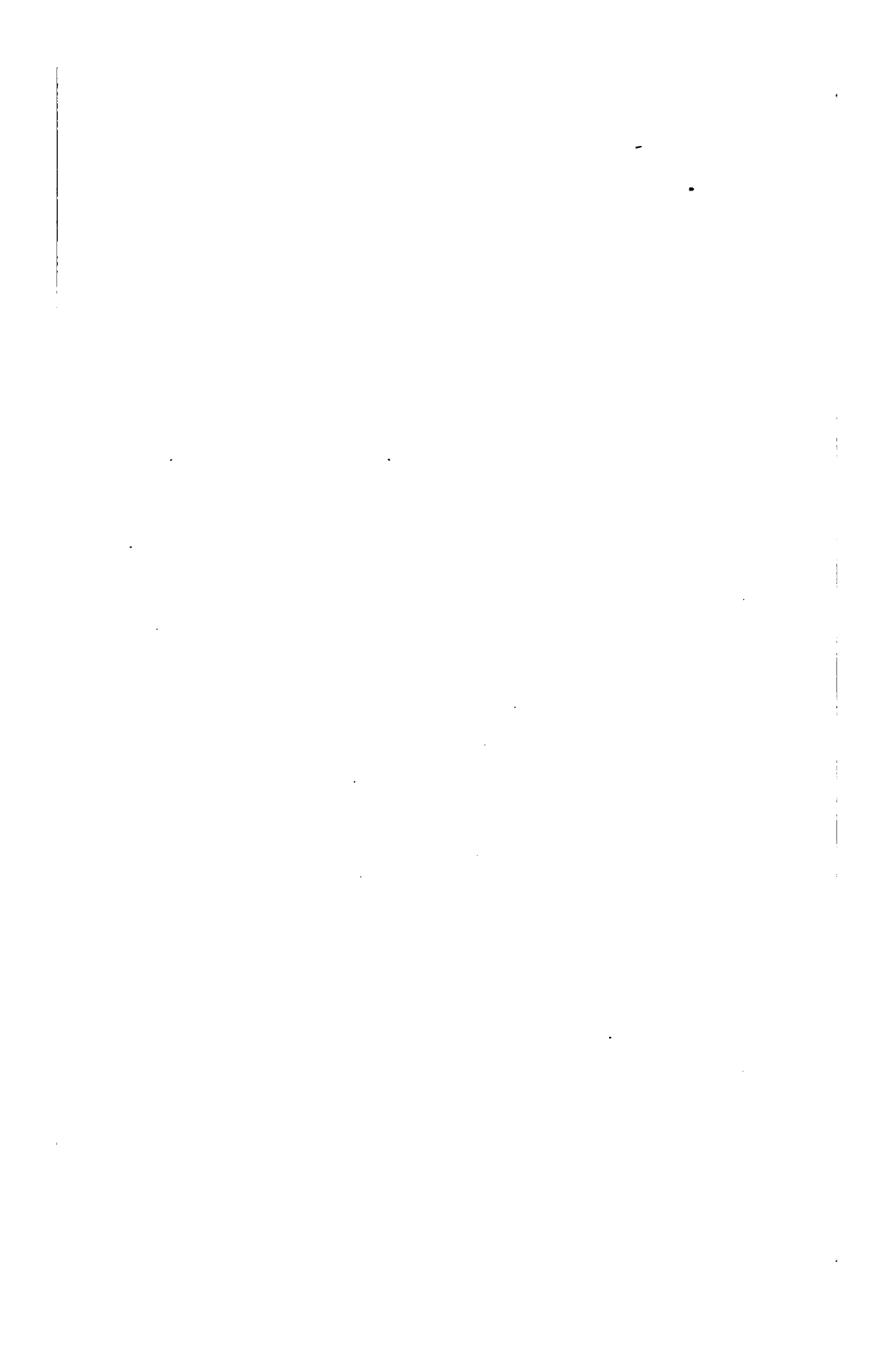
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TABLES AND FORMULAS.

This volume contains all the principal Tables, Rules, and Formulas occurring in the Instruction Papers of the Course. They have been collected and placed in this volume in order to make them convenient for ready reference, so that the student will not be obliged to search the Instruction Papers to find them.

The various Rules and Formulas are here grouped under the titles of the Instruction Papers in which they occur. Following each rule and formula are its number and also that of the article of the Instruction Paper in which it is discussed. These numbers may be readily found in the text by noting the section number on the headline at the top of the page. Thus: on page 91 of this volume we see that the formula for "Discharge of Pump" is followed by "**(191)**," the number of the formula, and by "Art. **2292**," the article in which it occurs; and that "§ 21" is on the headline. Since § 21 is in Vol. II, we look in Vol. II for § 21, and through this section until Art. **2292** is found.



TABLES
OF
NATURAL SINES, COSINES.
TANGENTS,
AND COTANGENTS

GIVING THE VALUES OF THE FUNCTIONS FOR
ALL DEGREES AND MINUTES FROM
0° TO 90°

NATURAL SINES AND COSINES.

3

°	0°		1°		2°		3°		4°		°
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.00000	1.	.01745	.99985	.03490	.99939	.05234	.99863	.06976	.99756	60
1	.00029	1.	.01774	.99984	.03519	.99938	.05263	.99861	.07005	.99754	59
2	.00058	1.	.01803	.99984	.03548	.99937	.05292	.99860	.07034	.99752	58
3	.00087	1.	.01832	.99983	.03577	.99936	.05321	.99858	.07063	.99750	57
4	.00116	1.	.01862	.99983	.03606	.99935	.05350	.99857	.07092	.99748	56
5	.00145	1.	.01891	.99982	.03635	.99934	.05379	.99855	.07121	.99746	55
6	.00175	1.	.01920	.99982	.03664	.99933	.05408	.99854	.07150	.99744	54
7	.00204	1.	.01949	.99981	.03693	.99932	.05437	.99852	.07179	.99742	53
8	.00233	1.	.01978	.99980	.03723	.99931	.05466	.99851	.07208	.99740	52
9	.00262	1.	.02007	.99980	.03752	.99930	.05495	.99849	.07237	.99738	51
10	.00291	1.	.02036	.99979	.03781	.99929	.05524	.99847	.07266	.99736	50
11	.00320	.99999	.02065	.99979	.03810	.99927	.05553	.99846	.07295	.99734	49
12	.00349	.99999	.02094	.99978	.03839	.99926	.05582	.99844	.07324	.99732	48
13	.00378	.99999	.02123	.99977	.03868	.99925	.05611	.99842	.07353	.99729	47
14	.00407	.99999	.02152	.99977	.03897	.99924	.05640	.99841	.07382	.99727	46
15	.00436	.99999	.02181	.99976	.03926	.99923	.05669	.99839	.07411	.99725	45
16	.00465	.99999	.02211	.99976	.03955	.99922	.05698	.99838	.07440	.99723	44
17	.00495	.99999	.02240	.99975	.03984	.99921	.05727	.99836	.07469	.99721	43
18	.00524	.99999	.02269	.99974	.04013	.99919	.05756	.99834	.07498	.99719	42
19	.00553	.99998	.02298	.99974	.04042	.99918	.05785	.99833	.07527	.99717	41
20	.00582	.99998	.02327	.99973	.04071	.99917	.05814	.99831	.07556	.99714	40
21	.00611	.99998	.02356	.99972	.04100	.99916	.05844	.99829	.07585	.99712	39
22	.00640	.99998	.02385	.99972	.04129	.99915	.05873	.99827	.07614	.99710	38
23	.00669	.99998	.02414	.99971	.04159	.99913	.05902	.99826	.07643	.99708	37
24	.00698	.99998	.02443	.99970	.04188	.99912	.05931	.99824	.07672	.99705	36
25	.00727	.99997	.02472	.99969	.04217	.99911	.05960	.99822	.07701	.99703	35
26	.00756	.99997	.02501	.99969	.04246	.99910	.05989	.99821	.07730	.99701	34
27	.00785	.99997	.02530	.99968	.04275	.99909	.06018	.99819	.07759	.99699	33
28	.00814	.99997	.02559	.99967	.04304	.99907	.06047	.99817	.07788	.99696	32
29	.00844	.99996	.02589	.99966	.04333	.99906	.06076	.99815	.07817	.99694	31
30	.00873	.99996	.02618	.99966	.04362	.99905	.06105	.99813	.07846	.99692	30
31	.00902	.99996	.02647	.99965	.04391	.99904	.06134	.99812	.07875	.99690	29
32	.00931	.99996	.02676	.99964	.04420	.99902	.06163	.99810	.07904	.99687	28
33	.00960	.99995	.02705	.99963	.04449	.99901	.06192	.99808	.07933	.99685	27
34	.00989	.99995	.02734	.99963	.04478	.99900	.06221	.99806	.07962	.99683	26
35	.01018	.99995	.02763	.99962	.04507	.99898	.06250	.99804	.07991	.99680	25
36	.01047	.99995	.02792	.99961	.04536	.99897	.06279	.99803	.08020	.99678	24
37	.01076	.99994	.02821	.99960	.04565	.99896	.06308	.99801	.08049	.99676	23
38	.01105	.99994	.02850	.99959	.04594	.99894	.06337	.99799	.08078	.99673	22
39	.01134	.99994	.02879	.99959	.04623	.99893	.06366	.99797	.08107	.99671	21
40	.01164	.99993	.02908	.99958	.04653	.99892	.06395	.99795	.08136	.99668	20
41	.01193	.99993	.02938	.99957	.04682	.99890	.06424	.99793	.08165	.99666	19
42	.01222	.99993	.02967	.99956	.04711	.99889	.06453	.99792	.08194	.99664	18
43	.01251	.99992	.02996	.99955	.04740	.99888	.06482	.99790	.08223	.99661	17
44	.01280	.99992	.03025	.99954	.04769	.99886	.06511	.99788	.08252	.99659	16
45	.01309	.99991	.03054	.99953	.04798	.99885	.06540	.99786	.08281	.99657	15
46	.01338	.99991	.03083	.99952	.04827	.99883	.06569	.99784	.08310	.99654	14
47	.01367	.99991	.03112	.99952	.04856	.99882	.06598	.99782	.08339	.99652	13
48	.01396	.99990	.03141	.99951	.04885	.99881	.06627	.99780	.08368	.99649	12
49	.01425	.99990	.03170	.99950	.04914	.99879	.06656	.99778	.08397	.99647	11
50	.01454	.99989	.03199	.99949	.04943	.99878	.06685	.99776	.08426	.99644	10
51	.01483	.99989	.03228	.99948	.04972	.99876	.06714	.99774	.08455	.99642	9
52	.01513	.99989	.03257	.99947	.05001	.99875	.06743	.99772	.08484	.99639	8
53	.01542	.99988	.03286	.99946	.05030	.99873	.06772	.99770	.08513	.99637	7
54	.01571	.99988	.03316	.99945	.05059	.99872	.06802	.99768	.08542	.99635	6
55	.01600	.99987	.03345	.99944	.05088	.99870	.06831	.99766	.08571	.99632	5
56	.01629	.99987	.03374	.99943	.05117	.99869	.06860	.99764	.08600	.99630	4
57	.01658	.99986	.03403	.99942	.05146	.99867	.06889	.99762	.08629	.99627	3
58	.01687	.99986	.03432	.99941	.05175	.99866	.06918	.99760	.08658	.99625	2
59	.01716	.99985	.03461	.99940	.05205	.99864	.06947	.99758	.08687	.99622	1
60	.01745	.99985	.03490	.99939	.05234	.99863	.06976	.99756	.08716	.99619	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	89°		88°		87°		86°		85°		

NATURAL SINES AND COSINES.

	5°		6°		7°		8°		9°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.08716	.99619	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	60
1	.08745	.99617	.10482	.99449	.12216	.99251	.13946	.99023	.15672	.98764	59
2	.08774	.99614	.10511	.99446	.12245	.99248	.13975	.99019	.15701	.98760	58
3	.08803	.99612	.10540	.99443	.12274	.99244	.14004	.99015	.15730	.98755	57
4	.08831	.99609	.10569	.99440	.12302	.99240	.14033	.99011	.15758	.98751	56
5	.08860	.99607	.10597	.99437	.12331	.99237	.14061	.99006	.15787	.98746	55
6	.08889	.99604	.10626	.99434	.12360	.99233	.14090	.99002	.15816	.98741	54
7	.08918	.99602	.10655	.99431	.12389	.99230	.14119	.98998	.15845	.98737	53
8	.08947	.99599	.10684	.99428	.12418	.99226	.14148	.98994	.15873	.98732	52
9	.08976	.99596	.10713	.99424	.12447	.99222	.14177	.98990	.15902	.98728	51
10	.09005	.99594	.10742	.99421	.12476	.99219	.14205	.98986	.15931	.98723	50
11	.09034	.99591	.10771	.99418	.12504	.99215	.14234	.98982	.15959	.98718	49
12	.09063	.99588	.10800	.99415	.12533	.99211	.14263	.98978	.15988	.98714	48
13	.09092	.99586	.10829	.99412	.12562	.99208	.14292	.98973	.16017	.98709	47
14	.09121	.99583	.10858	.99409	.12591	.99204	.14320	.98969	.16046	.98704	46
15	.09150	.99580	.10887	.99406	.12620	.99200	.14349	.98965	.16074	.98700	45
16	.09179	.99578	.10916	.99402	.12649	.99197	.14378	.98961	.16103	.98695	44
17	.09208	.99575	.10945	.99399	.12678	.99193	.14407	.98957	.16132	.98690	43
18	.09237	.99572	.10974	.99396	.12706	.99189	.14436	.98953	.16160	.98686	42
19	.09266	.99570	.11002	.99393	.12735	.99186	.14464	.98948	.16189	.98681	41
20	.09295	.99567	.11031	.99390	.12764	.99182	.14493	.98944	.16218	.98676	40
21	.09324	.99564	.11060	.99386	.12793	.99178	.14522	.98940	.16246	.98671	39
22	.09353	.99562	.11089	.99383	.12822	.99175	.14551	.98936	.16275	.98667	38
23	.09382	.99559	.11118	.99380	.12851	.99171	.14580	.98931	.16304	.98662	37
24	.09411	.99556	.11147	.99377	.12880	.99167	.14608	.98927	.16333	.98657	36
25	.09440	.99553	.11176	.99374	.12908	.99163	.14637	.98923	.16361	.98652	35
26	.09469	.99551	.11205	.99370	.12937	.99160	.14666	.98919	.16390	.98648	34
27	.09498	.99548	.11234	.99367	.12966	.99156	.14695	.98914	.16419	.98643	33
28	.09527	.99545	.11263	.99364	.12995	.99152	.14723	.98910	.16447	.98638	32
29	.09556	.99542	.11291	.99360	.13024	.99148	.14752	.98906	.16476	.98633	31
30	.09585	.99540	.11320	.99357	.13053	.99144	.14781	.98902	.16505	.98629	30
31	.09614	.99537	.11349	.99354	.13081	.99141	.14810	.98897	.16533	.98624	29
32	.09642	.99534	.11378	.99351	.13110	.99137	.14838	.98893	.16562	.98619	28
33	.09671	.99531	.11407	.99347	.13139	.99133	.14867	.98889	.16591	.98614	27
34	.09700	.99528	.11436	.99344	.13168	.99129	.14896	.98884	.16620	.98609	26
35	.09729	.99526	.11465	.99341	.13197	.99125	.14925	.98880	.16648	.98604	25
36	.09758	.99523	.11494	.99337	.13226	.99122	.14954	.98876	.16677	.98600	24
37	.09787	.99520	.11523	.99334	.13254	.99118	.14982	.98871	.16706	.98595	23
38	.09816	.99517	.11552	.99331	.13283	.99114	.15011	.98867	.16734	.98590	22
39	.09845	.99514	.11580	.99327	.13312	.99110	.15040	.98863	.16763	.98585	21
40	.09874	.99511	.11609	.99324	.13341	.99106	.15069	.98858	.16792	.98580	20
41	.09903	.99508	.11638	.99320	.13370	.99102	.15097	.98854	.16820	.98575	19
42	.09932	.99506	.11667	.99317	.13399	.99098	.15126	.98849	.16849	.98570	18
43	.09961	.99503	.11696	.99314	.13427	.99094	.15155	.98845	.16878	.98565	17
44	.09990	.99500	.11725	.99310	.13456	.99090	.15184	.98841	.16906	.98561	16
45	.10019	.99497	.11754	.99307	.13485	.99087	.15212	.98836	.16935	.98556	15
46	.10048	.99494	.11783	.99303	.13514	.99083	.15241	.98832	.16964	.98551	14
47	.10077	.99491	.11812	.99300	.13543	.99079	.15270	.98827	.16992	.98546	13
48	.10106	.99488	.11840	.99297	.13572	.99075	.15299	.98823	.17021	.98541	12
49	.10135	.99485	.11869	.99293	.13600	.99071	.15327	.98818	.17050	.98536	11
50	.10164	.99482	.11898	.99290	.13629	.99067	.15356	.98814	.17078	.98531	10
51	.10192	.99479	.11927	.99286	.13658	.99063	.15385	.98809	.17107	.98526	9
52	.10221	.99476	.11956	.99283	.13687	.99059	.15414	.98805	.17136	.98521	8
53	.10250	.99473	.11985	.99279	.13716	.99055	.15442	.98800	.17164	.98516	7
54	.10279	.99470	.12014	.99276	.13744	.99051	.15471	.98796	.17193	.98511	6
55	.10308	.99467	.12043	.99272	.13773	.99047	.15500	.98791	.17222	.98506	5
56	.10337	.99464	.12071	.99269	.13802	.99043	.15529	.98787	.17250	.98501	4
57	.10366	.99461	.12100	.99265	.13831	.99039	.15557	.98782	.17279	.98496	3
58	.10395	.99458	.12129	.99262	.13860	.99035	.15586	.98778	.17308	.98491	2
59	.10424	.99455	.12158	.99258	.13889	.99031	.15615	.98773	.17336	.98486	1
60	.10453	.99452	.12187	.99255	.13917	.99027	.15643	.98769	.17365	.98481	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	84°		83°		82°		81°		80°		

NATURAL SINES AND COSINES.

5

	10°		11°		12°		13°		14°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.17365	.98481	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	60
1	.17393	.98476	.19109	.98157	.20820	.97809	.22523	.97430	.24220	.97023	59
2	.17422	.98471	.19138	.98152	.20848	.97803	.22552	.97424	.24249	.97015	58
3	.17451	.98466	.19167	.98146	.20877	.97797	.22580	.97417	.24277	.97008	57
4	.17479	.98461	.19195	.98140	.20905	.97791	.22608	.97411	.24305	.97001	56
5	.17508	.98455	.19224	.98135	.20933	.97784	.22637	.97404	.24333	.96994	55
6	.17537	.98450	.19252	.98129	.20962	.97778	.22665	.97398	.24362	.96987	54
7	.17565	.98445	.19281	.98124	.20990	.97772	.22693	.97391	.24390	.96980	53
8	.17594	.98440	.19309	.98118	.21019	.97766	.22722	.97384	.24418	.96973	52
9	.17623	.98435	.19338	.98112	.21047	.97760	.22750	.97378	.24446	.96966	51
10	.17651	.98430	.19366	.98107	.21076	.97754	.22778	.97371	.24474	.96959	50
11	.17680	.98425	.19395	.98101	.21104	.97748	.22807	.97365	.24503	.96952	49
12	.17708	.98420	.19423	.98096	.21132	.97742	.22835	.97358	.24531	.96945	48
13	.17737	.98414	.19452	.98090	.21161	.97735	.22863	.97351	.24559	.96937	47
14	.17766	.98409	.19481	.98084	.21189	.97729	.22892	.97345	.24587	.96930	46
15	.17794	.98404	.19509	.98079	.21218	.97723	.22920	.97338	.24615	.96923	45
16	.17823	.98399	.19538	.98073	.21246	.97717	.22948	.97331	.24644	.96916	44
17	.17852	.98394	.19566	.98067	.21275	.97711	.22977	.97325	.24672	.96909	43
18	.17880	.98389	.19595	.98061	.21303	.97705	.23005	.97318	.24700	.96902	42
19	.17909	.98383	.19623	.98056	.21331	.97698	.23033	.97311	.24728	.96894	41
20	.17937	.98378	.19652	.98050	.21360	.97692	.23062	.97304	.24756	.96887	40
21	.17966	.98373	.19680	.98044	.21388	.97686	.23090	.97298	.24784	.96880	39
22	.17995	.98368	.19709	.98039	.21417	.97680	.23118	.97291	.24813	.96873	38
23	.18023	.98362	.19737	.98033	.21445	.97673	.23146	.97284	.24841	.96866	37
24	.18052	.98357	.19766	.98027	.21474	.97667	.23175	.97278	.24869	.96858	36
25	.18081	.98352	.19794	.98021	.21502	.97661	.23203	.97271	.24897	.96851	35
26	.18109	.98347	.19823	.98016	.21530	.97655	.23231	.97264	.24925	.96844	34
27	.18138	.98341	.19851	.98010	.21559	.97648	.23260	.97257	.24954	.96837	33
28	.18166	.98336	.19880	.98004	.21587	.97642	.23288	.97251	.24982	.96829	32
29	.18195	.98331	.19908	.97998	.21616	.97636	.23316	.97244	.25010	.96822	31
30	.18224	.98325	.19937	.97992	.21644	.97630	.23345	.97237	.25038	.96815	30
31	.18252	.98320	.19965	.97987	.21672	.97623	.23373	.97230	.25066	.96807	29
32	.18281	.98315	.19994	.97981	.21701	.97617	.23401	.97223	.25094	.96800	28
33	.18309	.98310	.20022	.97975	.21729	.97611	.23429	.97217	.25122	.96793	27
34	.18338	.98304	.20051	.97969	.21758	.97604	.23458	.97210	.25151	.96786	26
35	.18367	.98299	.20079	.97963	.21786	.97598	.23486	.97203	.25179	.96778	25
36	.18395	.98294	.20108	.97958	.21814	.97592	.23514	.97196	.25207	.96771	24
37	.18424	.98288	.20136	.97952	.21843	.97585	.23542	.97189	.25235	.96764	23
38	.18452	.98283	.20165	.97946	.21871	.97579	.23571	.97182	.25263	.96756	22
39	.18481	.98277	.20193	.97940	.21899	.97573	.23599	.97176	.25291	.96749	21
40	.18509	.98272	.20222	.97934	.21928	.97566	.23627	.97169	.25320	.96742	20
41	.18538	.98267	.20250	.97928	.21956	.97560	.23656	.97162	.25348	.96734	19
42	.18567	.98261	.20279	.97922	.21985	.97553	.23684	.97155	.25376	.96727	18
43	.18595	.98256	.20307	.97916	.22013	.97547	.23712	.97148	.25404	.96719	17
44	.18624	.98250	.20336	.97910	.22041	.97541	.23740	.97141	.25432	.96712	16
45	.18652	.98245	.20364	.97905	.22070	.97534	.23769	.97134	.25460	.96705	15
46	.18681	.98240	.20393	.97899	.22098	.97528	.23797	.97127	.25488	.96697	14
47	.18710	.98234	.20421	.97893	.22126	.97521	.23825	.97120	.25516	.96690	13
48	.18738	.98229	.20450	.97887	.22155	.97515	.23853	.97113	.25545	.96682	12
49	.18767	.98223	.20478	.97881	.22183	.97508	.23882	.97106	.25573	.96675	11
50	.18795	.98218	.20507	.97875	.22212	.97502	.23910	.97100	.25601	.96667	10
51	.18824	.98212	.20535	.97869	.22240	.97496	.23938	.97093	.25629	.96660	9
52	.18852	.98207	.20563	.97863	.22268	.97489	.23966	.97086	.25657	.96653	8
53	.18881	.98201	.20592	.97857	.22297	.97483	.23995	.97079	.25685	.96645	7
54	.18910	.98196	.20620	.97851	.22325	.97476	.24023	.97072	.25713	.96638	6
55	.18938	.98190	.20649	.97845	.22353	.97470	.24051	.97065	.25741	.96630	5
56	.18967	.98185	.20677	.97839	.22382	.97463	.24079	.97058	.25769	.96623	4
57	.18995	.98179	.20706	.97833	.22410	.97457	.24108	.97051	.25797	.96615	3
58	.19024	.98174	.20734	.97827	.22438	.97450	.24136	.97044	.25826	.96608	2
59	.19052	.98168	.20763	.97821	.22467	.97444	.24164	.97037	.25854	.96600	1
60	.19081	.98163	.20791	.97815	.22495	.97437	.24192	.97030	.25882	.96593	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	79°		78°		77°		76°		75°		

	15°		16°		17°		18°		19°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.25682	.95593	.27564	.96126	.29237	.95630	.30902	.95106	.32557	.94552	60
1	.25910	.95585	.27592	.96118	.29265	.95622	.30929	.95097	.32584	.94542	59
2	.25938	.95578	.27620	.96110	.29293	.95613	.30957	.95088	.32612	.94533	58
3	.25966	.95570	.27648	.96102	.29321	.95605	.30985	.95079	.32639	.94523	57
4	.25994	.95562	.27676	.96094	.29348	.95596	.31012	.95070	.32667	.94514	56
5	.26022	.95555	.27704	.96086	.29376	.95588	.31040	.95061	.32694	.94504	55
6	.26050	.95547	.27731	.96078	.29404	.95579	.31068	.95052	.32722	.94495	54
7	.26079	.95540	.27759	.96070	.29432	.95571	.31095	.95043	.32749	.94485	53
8	.26107	.95532	.27787	.96062	.29460	.95562	.31123	.95033	.32777	.94476	52
9	.26135	.95524	.27815	.96054	.29487	.95554	.31151	.95024	.32804	.94466	51
10	.26163	.95517	.27843	.96046	.29515	.95545	.31178	.95015	.32832	.94457	50
11	.26191	.95509	.27871	.96037	.29543	.95536	.31206	.95006	.32859	.94447	49
12	.26219	.95502	.27899	.96029	.29571	.95528	.31233	.94997	.32887	.94438	48
13	.26247	.95494	.27927	.96021	.29599	.95519	.31261	.94988	.32914	.94428	47
14	.26275	.95486	.27955	.96013	.29626	.95511	.31289	.94979	.32942	.94418	46
15	.26303	.95479	.27983	.96005	.29654	.95502	.31316	.94970	.32969	.94409	45
16	.26331	.95471	.28011	.95997	.29682	.95493	.31344	.94961	.32997	.94400	44
17	.26359	.95463	.28039	.95989	.29710	.95485	.31372	.94952	.33024	.94390	43
18	.26387	.95456	.28067	.95981	.29737	.95476	.31399	.94943	.33051	.94380	42
19	.26415	.95448	.28095	.95972	.29765	.95467	.31427	.94933	.33079	.94370	41
20	.26443	.95440	.28123	.95964	.29793	.95459	.31454	.94924	.33106	.94361	40
21	.26471	.95433	.28150	.95956	.29821	.95450	.31482	.94915	.33134	.94351	39
22	.26500	.95425	.28178	.95948	.29849	.95441	.31510	.94906	.33161	.94342	38
23	.26528	.95417	.28206	.95940	.29876	.95433	.31537	.94897	.33189	.94332	37
24	.26556	.95410	.28234	.95931	.29904	.95424	.31565	.94888	.33216	.94322	36
25	.26584	.95402	.28262	.95923	.29932	.95415	.31593	.94878	.33244	.94313	35
26	.26612	.95394	.28290	.95915	.29960	.95407	.31620	.94869	.33271	.94303	34
27	.26640	.95386	.28318	.95907	.29987	.95398	.31648	.94860	.33298	.94293	33
28	.26668	.95379	.28346	.95898	.30015	.95389	.31675	.94851	.33326	.94284	32
29	.26696	.95371	.28374	.95890	.30043	.95380	.31703	.94842	.33353	.94274	31
30	.26724	.95363	.28402	.95882	.30071	.95372	.31730	.94832	.33381	.94264	30
31	.26752	.95355	.28429	.95874	.30098	.95363	.31758	.94823	.33408	.94254	29
32	.26780	.95347	.28457	.95865	.30126	.95354	.31786	.94814	.33436	.94245	28
33	.26808	.95340	.28485	.95857	.30154	.95345	.31813	.94805	.33463	.94235	27
34	.26836	.95332	.28513	.95849	.30182	.95337	.31841	.94795	.33490	.94225	26
35	.26864	.95324	.28541	.95841	.30209	.95328	.31868	.94786	.33518	.94215	25
36	.26892	.95316	.28569	.95832	.30237	.95319	.31896	.94777	.33545	.94206	24
37	.26920	.95308	.28597	.95824	.30265	.95310	.31923	.94768	.33573	.94196	23
38	.26948	.95301	.28625	.95816	.30292	.95301	.31951	.94758	.33600	.94186	22
39	.26976	.95293	.28652	.95807	.30320	.95293	.31979	.94749	.33627	.94176	21
40	.27004	.95285	.28680	.95799	.30348	.95284	.32006	.94740	.33655	.94167	20
41	.27032	.95277	.28708	.95791	.30376	.95275	.32034	.94730	.33682	.94157	19
42	.27060	.95269	.28736	.95782	.30403	.95266	.32061	.94721	.33710	.94147	18
43	.27088	.95261	.28764	.95774	.30431	.95257	.32089	.94712	.33737	.94137	17
44	.27116	.95253	.28792	.95766	.30459	.95248	.32116	.94702	.33764	.94127	16
45	.27144	.95246	.28820	.95757	.30486	.95240	.32144	.94693	.33792	.94118	15
46	.27172	.95238	.28847	.95749	.30514	.95231	.32171	.94684	.33819	.94108	14
47	.27200	.95230	.28875	.95740	.30542	.95222	.32199	.94674	.33846	.94098	13
48	.27228	.95222	.28903	.95732	.30570	.95213	.32227	.94665	.33874	.94088	12
49	.27256	.95214	.28931	.95724	.30597	.95204	.32254	.94656	.33901	.94078	11
50	.27284	.95206	.28959	.95715	.30625	.95195	.32282	.94646	.33929	.94068	10
51	.27312	.95198	.28987	.95707	.30653	.95186	.32309	.94637	.33956	.94058	9
52	.27340	.95190	.29015	.95698	.30680	.95177	.32337	.94627	.33983	.94049	8
53	.27368	.95182	.29042	.95690	.30708	.95168	.32364	.94618	.34011	.94039	7
54	.27396	.95174	.29070	.95681	.30736	.95159	.32392	.94609	.34038	.94029	6
55	.27424	.95166	.29098	.95673	.30763	.95150	.32419	.94599	.34065	.94019	5
56	.27452	.95158	.29126	.95664	.30791	.95142	.32447	.94590	.34093	.94009	4
57	.27480	.95150	.29154	.95656	.30819	.95133	.32474	.94580	.34120	.93999	3
58	.27508	.95142	.29182	.95647	.30846	.95124	.32502	.94571	.34147	.93989	2
59	.27536	.95134	.29209	.95639	.30874	.95115	.32529	.94561	.34175	.93979	1
60	.27564	.95126	.29237	.95630	.30902	.95106	.32557	.94552	.34202	.93969	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	74°		73°		72°		71°		70°		

7

	20°		21°		22°		23°		24°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
1	.34202	.93969	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	60
2	.34229	.93959	.35864	.93348	.37488	.92707	.39100	.92039	.40700	.91343	59
3	.34257	.93949	.35891	.93337	.37515	.92697	.39127	.92028	.40727	.91331	58
4	.34284	.93939	.35918	.93327	.37542	.92686	.39153	.92016	.40753	.91319	57
5	.34311	.93929	.35945	.93316	.37569	.92675	.39180	.92005	.40780	.91307	56
6	.34339	.93919	.35973	.93306	.37595	.92664	.39207	.91994	.40806	.91295	55
7	.34366	.93909	.36000	.93295	.37622	.92653	.39234	.91982	.40833	.91283	54
8	.34393	.93899	.36027	.93285	.37649	.92642	.39260	.91971	.40860	.91272	53
9	.34421	.93889	.36054	.93274	.37676	.92631	.39287	.91959	.40886	.91260	52
10	.34448	.93879	.36081	.93264	.37703	.92620	.39314	.91948	.40913	.91248	51
	.34475	.93869	.36108	.93253	.37730	.92609	.39341	.91936	.40939	.91236	50
11	.34503	.93859	.36135	.93243	.37757	.92598	.39367	.91925	.40966	.91224	49
12	.34530	.93849	.36162	.93232	.37784	.92587	.39394	.91914	.40992	.91212	48
13	.34557	.93839	.36190	.93222	.37811	.92576	.39421	.91902	.41019	.91200	47
14	.34584	.93829	.36217	.93211	.37838	.92565	.39448	.91891	.41045	.91188	46
15	.34612	.93819	.36244	.93201	.37865	.92554	.39474	.91879	.41072	.91176	45
16	.34639	.93809	.36271	.93190	.37892	.92543	.39501	.91868	.41098	.91164	44
17	.34666	.93799	.36298	.93180	.37919	.92532	.39528	.91856	.41125	.91152	43
18	.34694	.93789	.36325	.93169	.37946	.92521	.39555	.91845	.41151	.91140	42
19	.34721	.93779	.36352	.93159	.37973	.92510	.39581	.91833	.41178	.91128	41
20	.34748	.93769	.36379	.93148	.37999	.92499	.39608	.91822	.41204	.91116	40
21	.34775	.93759	.36406	.93137	.38026	.92488	.39635	.91810	.41231	.91104	39
22	.34803	.93748	.36434	.93127	.38053	.92477	.39661	.91799	.41257	.91092	38
23	.34830	.93738	.36461	.93116	.38080	.92466	.39688	.91787	.41284	.91080	37
24	.34857	.93728	.36488	.93106	.38107	.92455	.39715	.91775	.41310	.91068	36
25	.34884	.93718	.36515	.93095	.38134	.92444	.39741	.91764	.41337	.91056	35
26	.34912	.93708	.36542	.93084	.38161	.92432	.39768	.91752	.41363	.91044	34
27	.34939	.93698	.36569	.93074	.38188	.92421	.39795	.91741	.41390	.91032	33
28	.34966	.93688	.36596	.93063	.38215	.92410	.39822	.91729	.41416	.91020	32
29	.34993	.93677	.36623	.93052	.38242	.92399	.39848	.91718	.41443	.91008	31
30	.35021	.93667	.36650	.93042	.38268	.92388	.39875	.91706	.41469	.90996	30
31	.35048	.93657	.36677	.93031	.38295	.92377	.39902	.91694	.41496	.90984	29
32	.35075	.93647	.36704	.93020	.38322	.92366	.39928	.91683	.41522	.90972	28
33	.35102	.93637	.36731	.93010	.38349	.92355	.39955	.91671	.41549	.90960	27
34	.35130	.93626	.36758	.92999	.38376	.92343	.39982	.91660	.41575	.90948	26
35	.35157	.93616	.36785	.92988	.38403	.92332	.40008	.91648	.41602	.90936	25
36	.35184	.93606	.36812	.92978	.38430	.92321	.40035	.91636	.41628	.90924	24
37	.35211	.93596	.36839	.92967	.38456	.92310	.40062	.91625	.41655	.90911	23
38	.35239	.93585	.36867	.92956	.38483	.92299	.40088	.91613	.41681	.90899	22
39	.35266	.93575	.36894	.92945	.38510	.92287	.40115	.91601	.41707	.90887	21
40	.35293	.93565	.36921	.92935	.38537	.92276	.40141	.91590	.41734	.90875	20
41	.35320	.93555	.36948	.92924	.38564	.92265	.40168	.91578	.41760	.90863	19
42	.35347	.93544	.36975	.92913	.38591	.92254	.40195	.91566	.41787	.90851	18
43	.35375	.93534	.37002	.92902	.38617	.92243	.40221	.91555	.41813	.90839	17
44	.35402	.93524	.37029	.92892	.38644	.92231	.40248	.91543	.41840	.90826	16
45	.35429	.93514	.37056	.92881	.38671	.92220	.40275	.91531	.41866	.90814	15
46	.35456	.93503	.37083	.92870	.38698	.92209	.40301	.91519	.41892	.90802	14
47	.35484	.93493	.37110	.92859	.38725	.92198	.40328	.91508	.41919	.90790	13
48	.35511	.93483	.37137	.92849	.38752	.92186	.40355	.91496	.41945	.90778	12
49	.35538	.93472	.37164	.92838	.38778	.92175	.40381	.91484	.41972	.90766	11
50	.35565	.93462	.37191	.92827	.38805	.92164	.40408	.91472	.41998	.90753	10
51	.35592	.93452	.37218	.92816	.38832	.92152	.40434	.91461	.42024	.90741	9
52	.35619	.93441	.37245	.92805	.38859	.92141	.40461	.91449	.42051	.90729	8
53	.35647	.93431	.37272	.92794	.38886	.92130	.40488	.91437	.42077	.90717	7
54	.35674	.93420	.37299	.92783	.38912	.92119	.40514	.91425	.42104	.90704	6
55	.35701	.93410	.37326	.92773	.38939	.92107	.40541	.91414	.42130	.90692	5
56	.35728	.93400	.37353	.92762	.38966	.92096	.40567	.91402	.42156	.90680	4
57	.35755	.93389	.37380	.92751	.38993	.92085	.40594	.91390	.42183	.90668	3
58	.35782	.93379	.37407	.92740	.39020	.92073	.40621	.91378	.42209	.90655	2
59	.35810	.93368	.37434	.92729	.39046	.92062	.40647	.91366	.42235	.90643	1
60	.35837	.93358	.37461	.92718	.39073	.92050	.40674	.91355	.42262	.90631	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	69°		68°		67°		66°		65°		

°	25°		26°		27°		28°		29°		°
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.42262	.90631	.43837	.89879	.45399	.89101	.46947	.88295	.48431	.87462	60
1	.42288	.90618	.43863	.89867	.45425	.89087	.46973	.88281	.48506	.87448	59
2	.42315	.90606	.43889	.89854	.45451	.89074	.46999	.88267	.48532	.87434	58
3	.42341	.90594	.43916	.89841	.45477	.89061	.47024	.88254	.48557	.87420	57
4	.42367	.90582	.43942	.89828	.45503	.89048	.47050	.88240	.48583	.87406	56
5	.42394	.90569	.43968	.89816	.45529	.89035	.47076	.88226	.48608	.87391	55
6	.42420	.90557	.43994	.89803	.45554	.89021	.47101	.88213	.48634	.87377	54
7	.42446	.90545	.44020	.89790	.45580	.89008	.47127	.88199	.48659	.87363	53
8	.42473	.90532	.44046	.89777	.45606	.88995	.47153	.88185	.48684	.87349	52
9	.42499	.90520	.44072	.89764	.45632	.88981	.47178	.88172	.48710	.87335	51
10	.42525	.90507	.44098	.89752	.45658	.88968	.47204	.88158	.48735	.87321	50
11	.42552	.90495	.44124	.89739	.45684	.88955	.47229	.88144	.48761	.87306	49
12	.42578	.90483	.44151	.89726	.45710	.88942	.47255	.88130	.48786	.87292	48
13	.42604	.90470	.44177	.89713	.45736	.88928	.47281	.88117	.48811	.87278	47
14	.42631	.90458	.44203	.89700	.45762	.88915	.47306	.88103	.48837	.87264	46
15	.42657	.90446	.44229	.89687	.45787	.88902	.47332	.88089	.48862	.87250	45
16	.42683	.90433	.44255	.89674	.45813	.88888	.47358	.88075	.48888	.87235	44
17	.42709	.90421	.44281	.89662	.45839	.88875	.47383	.88062	.48913	.87221	43
18	.42736	.90408	.44307	.89649	.45865	.88862	.47409	.88048	.48938	.87207	42
19	.42762	.90396	.44333	.89636	.45891	.88848	.47434	.88034	.48964	.87193	41
20	.42788	.90383	.44359	.89623	.45917	.88835	.47460	.88020	.48989	.87178	40
21	.42815	.90371	.44385	.89610	.45942	.88822	.47486	.88006	.49014	.87164	39
22	.42841	.90358	.44411	.89597	.45968	.88808	.47511	.87993	.49040	.87150	38
23	.42867	.90346	.44437	.89584	.45994	.88795	.47537	.87979	.49065	.87136	37
24	.42894	.90334	.44464	.89571	.46020	.88782	.47562	.87965	.49090	.87121	36
25	.42920	.90321	.44490	.89558	.46046	.88768	.47588	.87951	.49116	.87107	35
26	.42946	.90309	.44516	.89545	.46072	.88755	.47614	.87937	.49141	.87093	34
27	.42972	.90296	.44542	.89532	.46097	.88741	.47639	.87923	.49166	.87079	33
28	.42999	.90284	.44568	.89519	.46123	.88728	.47665	.87909	.49192	.87064	32
29	.43025	.90271	.44594	.89506	.46149	.88715	.47690	.87896	.49217	.87050	31
30	.43051	.90259	.44620	.89493	.46175	.88701	.47716	.87882	.49242	.87036	30
31	.43077	.90246	.44646	.89480	.46201	.88688	.47741	.87868	.49268	.87021	29
32	.43104	.90233	.44672	.89467	.46226	.88674	.47767	.87854	.49293	.87007	28
33	.43130	.90221	.44698	.89454	.46252	.88661	.47793	.87840	.49318	.86993	27
34	.43156	.90208	.44724	.89441	.46278	.88647	.47818	.87826	.49344	.86978	26
35	.43182	.90196	.44750	.89428	.46304	.88634	.47844	.87812	.49369	.86964	25
36	.43209	.90183	.44776	.89415	.46330	.88620	.47869	.87798	.49394	.86949	24
37	.43235	.90171	.44802	.89402	.46355	.88607	.47895	.87784	.49419	.86935	23
38	.43261	.90158	.44828	.89389	.46381	.88593	.47920	.87770	.49445	.86921	22
39	.43287	.90146	.44854	.89376	.46407	.88580	.47946	.87756	.49470	.86906	21
40	.43313	.90133	.44880	.89363	.46433	.88566	.47971	.87743	.49495	.86892	20
41	.43340	.90120	.44906	.89350	.46458	.88553	.47997	.87729	.49521	.86878	19
42	.43366	.90108	.44932	.89337	.46484	.88539	.48022	.87715	.49546	.86863	18
43	.43392	.90095	.44958	.89324	.46510	.88526	.48048	.87701	.49571	.86849	17
44	.43418	.90082	.44984	.89311	.46536	.88512	.48073	.87687	.49596	.86834	16
45	.43444	.90070	.45010	.89298	.46561	.88499	.48099	.87673	.49622	.86820	15
46	.43471	.90057	.45036	.89285	.46587	.88485	.48124	.87659	.49647	.86805	14
47	.43497	.90045	.45062	.89272	.46613	.88472	.48150	.87645	.49672	.86791	13
48	.43523	.90032	.45088	.89259	.46639	.88458	.48175	.87631	.49697	.86777	12
49	.43549	.90019	.45114	.89245	.46664	.88445	.48201	.87617	.49723	.86762	11
50	.43575	.90007	.45140	.89232	.46690	.88431	.48226	.87603	.49748	.86748	10
51	.43602	.89994	.45166	.89219	.46716	.88417	.48252	.87589	.49773	.86733	9
52	.43628	.89981	.45192	.89206	.46742	.88404	.48277	.87575	.49798	.86719	8
53	.43654	.89968	.45218	.89193	.46767	.88390	.48303	.87561	.49824	.86704	7
54	.43680	.89956	.45244	.89180	.46793	.88377	.48328	.87546	.49849	.86690	6
55	.43706	.89943	.45269	.89167	.46819	.88363	.48354	.87532	.49874	.86675	5
56	.43733	.89930	.45295	.89153	.46844	.88349	.48379	.87518	.49899	.86661	4
57	.43759	.89918	.45321	.89140	.46870	.88336	.48405	.87504	.49924	.86646	3
58	.43785	.89905	.45347	.89127	.46896	.88322	.48430	.87490	.49950	.86632	2
59	.43811	.89892	.45373	.89114	.46921	.88309	.48456	.87476	.49975	.86617	1
60	.43837	.89879	.45399	.89101	.46947	.88295	.48481	.87462	.50000	.86603	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	64°		63°		62°		61°		60°		

9

	30°		31°		32°		33°		34°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.50000	.86603	.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	60
1	.50025	.86588	.51529	.85702	.53017	.84789	.54488	.83851	.55943	.82887	59
2	.50050	.86573	.51554	.85687	.53041	.84774	.54513	.83835	.55968	.82871	58
3	.50076	.86559	.51579	.85672	.53066	.84759	.54537	.83819	.55992	.82855	57
4	.50101	.86544	.51604	.85657	.53091	.84743	.54561	.83804	.56016	.82839	56
5	.50126	.86530	.51628	.85642	.53115	.84728	.54586	.83788	.56040	.82822	55
6	.50151	.86515	.51653	.85627	.53140	.84712	.54610	.83772	.56064	.82806	54
7	.50176	.86501	.51678	.85612	.53164	.84697	.54635	.83756	.56088	.82790	53
8	.50201	.86486	.51703	.85597	.53189	.84681	.54659	.83740	.56112	.82773	52
9	.50227	.86471	.51728	.85582	.53214	.84666	.54683	.83724	.56136	.82757	51
10	.50252	.86457	.51753	.85567	.53238	.84650	.54708	.83708	.56160	.82741	50
11	.50277	.86442	.51778	.85551	.53263	.84635	.54732	.83692	.56184	.82724	49
12	.50302	.86427	.51803	.85536	.53288	.84619	.54756	.83676	.56208	.82708	48
13	.50327	.86413	.51828	.85521	.53312	.84604	.54781	.83660	.56232	.82692	47
14	.50352	.86398	.51852	.85506	.53337	.84588	.54805	.83645	.56256	.82675	46
15	.50377	.86384	.51877	.85491	.53361	.84573	.54829	.83629	.56280	.82659	45
16	.50403	.86369	.51902	.85476	.53386	.84557	.54854	.83613	.56305	.82643	44
17	.50428	.86354	.51927	.85461	.53411	.84542	.54878	.83597	.56329	.82626	43
18	.50453	.86340	.51952	.85446	.53435	.84526	.54902	.83581	.56353	.82610	42
19	.50478	.86325	.51977	.85431	.53460	.84511	.54927	.83565	.56377	.82593	41
20	.50503	.86310	.52002	.85416	.53484	.84495	.54951	.83549	.56401	.82577	40
21	.50528	.86295	.52026	.85401	.53509	.84480	.54975	.83533	.56425	.82561	39
22	.50553	.86281	.52051	.85385	.53534	.84464	.54999	.83517	.56449	.82544	38
23	.50578	.86266	.52076	.85370	.53558	.84448	.55024	.83501	.56473	.82528	37
24	.50603	.86251	.52101	.85355	.53583	.84433	.55048	.83485	.56497	.82511	36
25	.50628	.86237	.52126	.85340	.53607	.84417	.55072	.83469	.56521	.82495	35
26	.50652	.86222	.52151	.85325	.53632	.84402	.55097	.83453	.56545	.82478	34
27	.50677	.86207	.52175	.85310	.53656	.84386	.55121	.83437	.56569	.82462	33
28	.50702	.86192	.52200	.85294	.53681	.84370	.55145	.83421	.56593	.82446	32
29	.50727	.86178	.52225	.85279	.53705	.84355	.55169	.83405	.56617	.82429	31
30	.50752	.86163	.52250	.85264	.53730	.84339	.55194	.83389	.56641	.82413	30
31	.50777	.86148	.52275	.85249	.53754	.84324	.55218	.83373	.56665	.82396	29
32	.50802	.86133	.52299	.85234	.53779	.84308	.55242	.83356	.56689	.82380	28
33	.50829	.86119	.52324	.85218	.53804	.84292	.55266	.83340	.56713	.82363	27
34	.50854	.86104	.52349	.85202	.53828	.84277	.55291	.83324	.56736	.82347	26
35	.50879	.86089	.52374	.85188	.53853	.84261	.55315	.83308	.56760	.82330	25
36	.50904	.86074	.52399	.85173	.53877	.84245	.55339	.83292	.56784	.82314	24
37	.50929	.86059	.52423	.85157	.53902	.84230	.55363	.83276	.56808	.82297	23
38	.50954	.86045	.52448	.85142	.53926	.84214	.55388	.83260	.56832	.82281	22
39	.50979	.86030	.52473	.85127	.53951	.84198	.55412	.83244	.56856	.82264	21
40	.51004	.86015	.52498	.85112	.53975	.84182	.55436	.83228	.56880	.82248	20
41	.51029	.86000	.52522	.85096	.54000	.84167	.55460	.83212	.56904	.82231	19
42	.51054	.85985	.52547	.85081	.54024	.84151	.55484	.83195	.56928	.82214	18
43	.51079	.85970	.52572	.85066	.54049	.84135	.55509	.83179	.56952	.82198	17
44	.51104	.85955	.52597	.85051	.54073	.84120	.55533	.83163	.56976	.82181	16
45	.51129	.85941	.52621	.85035	.54097	.84104	.55557	.83147	.57000	.82165	15
46	.51154	.85926	.52646	.85020	.54122	.84088	.55581	.83131	.57024	.82148	14
47	.51179	.85911	.52671	.85005	.54146	.84072	.55605	.83115	.57047	.82132	13
48	.51204	.85896	.52696	.84989	.54171	.84057	.55629	.83098	.57071	.82115	12
49	.51229	.85881	.52720	.84974	.54195	.84041	.55654	.83082	.57095	.82098	11
50	.51254	.85866	.52745	.84959	.54220	.84025	.55678	.83066	.57119	.82082	10
51	.51279	.85851	.52770	.84943	.54244	.84009	.55702	.83050	.57143	.82065	9
52	.51304	.85836	.52794	.84928	.54269	.83994	.55726	.83034	.57167	.82048	8
53	.51329	.85821	.52819	.84913	.54293	.83978	.55750	.83017	.57191	.82032	7
54	.51354	.85806	.52844	.84897	.54317	.83962	.55775	.83001	.57215	.82015	6
55	.51379	.85792	.52869	.84882	.54342	.83946	.55799	.82985	.57239	.81999	5
56	.51404	.85777	.52893	.84866	.54366	.83930	.55823	.82969	.57263	.81982	4
57	.51429	.85762	.52918	.84851	.54391	.83915	.55847	.82953	.57287	.81965	3
58	.51454	.85747	.52943	.84836	.54415	.83899	.55871	.82937	.57310	.81949	2
59	.51479	.85732	.52967	.84820	.54440	.83883	.55895	.82920	.57334	.81932	1
60	.51504	.85717	.52992	.84805	.54464	.83867	.55919	.82904	.57358	.81915	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	59°		58°		57°		56°		55°		

	35°		36°		37°		38°		39°		
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.57358	.81915	.58770	.80902	.60182	.79864	.61566	.78801	.62932	.77715	60
1	.57381	.81899	.58802	.80885	.60205	.79846	.61589	.78783	.62955	.77696	59
2	.57405	.81882	.58826	.80867	.60228	.79829	.61612	.78765	.62977	.77678	58
3	.57429	.81865	.58849	.80850	.60251	.79811	.61635	.78747	.63000	.77660	57
4	.57453	.81848	.58873	.80833	.60274	.79793	.61658	.78729	.63022	.77641	56
5	.57477	.81832	.58896	.80816	.60298	.79776	.61681	.78711	.63045	.77623	55
6	.57501	.81815	.58920	.80799	.60321	.79758	.61704	.78694	.63068	.77605	54
7	.57524	.81798	.58943	.80782	.60344	.79741	.61726	.78676	.63090	.77586	53
8	.57548	.81782	.58967	.80765	.60367	.79723	.61749	.78658	.63113	.77568	52
9	.57572	.81765	.58990	.80748	.60390	.79706	.61772	.78640	.63135	.77550	51
10	.57596	.81748	.59014	.80730	.60414	.79688	.61795	.78622	.63158	.77531	50
11	.57619	.81731	.59037	.80713	.60437	.79671	.61818	.78604	.63180	.77513	49
12	.57643	.81714	.59061	.80696	.60460	.79653	.61841	.78586	.63203	.77494	48
13	.57667	.81698	.59084	.80679	.60483	.79635	.61864	.78568	.63225	.77476	47
14	.57691	.81681	.59108	.80662	.60506	.79618	.61887	.78550	.63248	.77458	46
15	.57715	.81664	.59131	.80644	.60529	.79600	.61909	.78532	.63271	.77439	45
16	.57738	.81647	.59154	.80627	.60553	.79583	.61932	.78514	.63293	.77421	44
17	.57762	.81631	.59178	.80610	.60576	.79565	.61955	.78496	.63316	.77402	43
18	.57786	.81614	.59201	.80593	.60599	.79547	.61978	.78478	.63338	.77384	42
19	.57810	.81597	.59225	.80576	.60622	.79530	.62001	.78460	.63361	.77366	41
20	.57833	.81580	.59248	.80558	.60645	.79512	.62024	.78442	.63383	.77347	40
21	.57857	.81563	.59272	.80541	.60668	.79494	.62046	.78424	.63406	.77329	39
22	.57881	.81546	.59295	.80524	.60691	.79477	.62069	.78405	.63428	.77310	38
23	.57904	.81530	.59318	.80507	.60714	.79459	.62092	.78387	.63451	.77292	37
24	.57928	.81513	.59342	.80489	.60738	.79441	.62115	.78369	.63473	.77273	36
25	.57952	.81496	.59365	.80472	.60761	.79424	.62138	.78351	.63496	.77255	35
26	.57976	.81479	.59389	.80455	.60784	.79406	.62160	.78333	.63518	.77236	34
27	.57999	.81462	.59412	.80438	.60807	.79388	.62183	.78315	.63540	.77218	33
28	.58023	.81445	.59436	.80420	.60830	.79371	.62206	.78297	.63563	.77199	32
29	.58047	.81428	.59459	.80403	.60853	.79353	.62229	.78279	.63585	.77181	31
30	.58070	.81412	.59482	.80386	.60876	.79335	.62251	.78261	.63608	.77162	30
31	.58094	.81395	.59506	.80368	.60899	.79318	.62274	.78243	.63630	.77144	29
32	.58118	.81378	.59529	.80351	.60922	.79300	.62297	.78225	.63653	.77125	28
33	.58141	.81361	.59552	.80334	.60945	.79282	.62320	.78206	.63675	.77107	27
34	.58165	.81344	.59576	.80316	.60968	.79264	.62342	.78188	.63698	.77088	26
35	.58189	.81327	.59599	.80299	.60991	.79247	.62365	.78170	.63720	.77070	25
36	.58212	.81310	.59622	.80282	.61015	.79229	.62388	.78152	.63742	.77051	24
37	.58236	.81293	.59646	.80264	.61038	.79211	.62411	.78134	.63765	.77033	23
38	.58260	.81276	.59669	.80247	.61061	.79193	.62433	.78116	.63787	.77014	22
39	.58283	.81259	.59693	.80230	.61084	.79176	.62456	.78098	.63810	.76996	21
40	.58307	.81242	.59716	.80212	.61107	.79158	.62479	.78079	.63832	.76977	20
41	.58330	.81225	.59739	.80195	.61130	.79140	.62502	.78061	.63854	.76959	19
42	.58354	.81208	.59763	.80178	.61153	.79122	.62524	.78043	.63877	.76940	18
43	.58378	.81191	.59786	.80160	.61176	.79105	.62547	.78025	.63899	.76921	17
44	.58401	.81174	.59809	.80143	.61199	.79087	.62570	.78007	.63922	.76903	16
45	.58425	.81157	.59832	.80125	.61222	.79069	.62592	.77988	.63944	.76884	15
46	.58449	.81140	.59856	.80108	.61245	.79051	.62615	.77970	.63966	.76866	14
47	.58472	.81123	.59879	.80091	.61268	.79033	.62638	.77952	.63989	.76847	13
48	.58496	.81106	.59902	.80073	.61291	.79016	.62660	.77934	.64011	.76828	12
49	.58519	.81089	.59926	.80056	.61314	.78998	.62683	.77916	.64033	.76810	11
50	.58543	.81072	.59949	.80038	.61337	.78980	.62706	.77897	.64056	.76791	10
51	.58567	.81055	.59972	.80021	.61360	.78962	.62728	.77879	.64078	.76772	9
52	.58590	.81038	.59995	.80003	.61383	.78944	.62751	.77861	.64100	.76754	8
53	.58614	.81021	.60019	.79986	.61406	.78926	.62774	.77843	.64123	.76735	7
54	.58637	.81004	.60042	.79968	.61429	.78908	.62796	.77824	.64145	.76717	6
55	.58661	.80987	.60065	.79951	.61451	.78891	.62819	.77806	.64167	.76698	5
56	.58684	.80970	.60089	.79934	.61474	.78873	.62842	.77788	.64190	.76679	4
57	.58708	.80953	.60112	.79916	.61497	.78855	.62864	.77769	.64212	.76661	3
58	.58731	.80936	.60135	.79899	.61520	.78837	.62887	.77751	.64234	.76642	2
59	.58755	.80919	.60158	.79881	.61543	.78819	.62909	.77733	.64256	.76623	1
60	.58779	.80902	.60182	.79864	.61566	.78801	.62932	.77715	.64279	.76604	0
	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	
	54°		53°		52°		51°		50°		

11

°	40°		41°		42°		43°		44°		°
	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	
0	.64279	.76604	.65606	.75471	.66913	.74314	.68200	.73135	.69466	.71934	60
1	.64301	.76586	.65588	.75452	.66935	.74295	.68221	.73116	.69487	.71914	59
2	.64323	.76567	.65569	.75433	.66956	.74276	.68242	.73096	.69508	.71894	58
3	.64346	.76548	.65549	.75414	.66978	.74256	.68264	.73076	.69529	.71873	57
4	.64368	.76530	.65530	.75395	.66999	.74237	.68285	.73056	.69549	.71853	56
5	.64390	.76511	.65511	.75375	.67021	.74217	.68306	.73036	.69570	.71833	55
6	.64412	.76492	.65492	.75356	.67043	.74198	.68327	.73016	.69591	.71813	54
7	.64435	.76473	.65473	.75337	.67064	.74178	.68349	.72996	.69612	.71792	53
8	.64457	.76455	.65455	.75318	.67086	.74159	.68370	.72976	.69633	.71772	52
9	.64479	.76436	.65436	.75299	.67107	.74139	.68391	.72957	.69654	.71752	51
10	.64501	.76417	.65417	.75280	.67129	.74120	.68412	.72937	.69675	.71732	50
11	.64524	.76398	.65398	.75261	.67151	.74100	.68434	.72917	.69696	.71711	49
12	.64546	.76379	.65379	.75242	.67172	.74080	.68455	.72897	.69717	.71691	48
13	.64568	.76361	.65361	.75222	.67194	.74061	.68476	.72877	.69737	.71671	47
14	.64590	.76342	.65342	.75203	.67215	.74041	.68497	.72857	.69758	.71650	46
15	.64612	.76323	.65323	.75184	.67237	.74022	.68518	.72837	.69779	.71630	45
16	.64635	.76304	.65304	.75165	.67258	.74002	.68539	.72817	.69800	.71610	44
17	.64657	.76286	.65286	.75146	.67280	.73983	.68561	.72797	.69821	.71590	43
18	.64679	.76267	.65267	.75126	.67301	.73963	.68582	.72777	.69842	.71569	42
19	.64701	.76248	.65248	.75107	.67323	.73944	.68603	.72757	.69862	.71549	41
20	.64723	.76229	.65229	.75088	.67344	.73924	.68624	.72737	.69883	.71529	40
21	.64746	.76210	.65210	.75069	.67366	.73904	.68645	.72717	.69904	.71508	39
22	.64768	.76192	.65192	.75050	.67387	.73885	.68666	.72697	.69925	.71488	38
23	.64790	.76173	.65173	.75030	.67409	.73865	.68688	.72677	.69946	.71468	37
24	.64812	.76154	.65154	.75011	.67430	.73846	.68709	.72657	.69966	.71447	36
25	.64835	.76135	.65135	.74992	.67452	.73826	.68730	.72637	.69987	.71427	35
26	.64856	.76116	.65116	.74973	.67473	.73806	.68751	.72617	.70008	.71407	34
27	.64878	.76097	.65097	.74953	.67495	.73787	.68772	.72597	.70029	.71386	33
28	.64900	.76078	.65078	.74934	.67516	.73767	.68793	.72577	.70049	.71366	32
29	.64922	.76059	.65059	.74915	.67538	.73747	.68814	.72557	.70070	.71345	31
30	.64945	.76041	.65041	.74896	.67559	.73728	.68835	.72537	.70091	.71325	30
31	.64967	.76022	.65022	.74876	.67580	.73708	.68857	.72517	.70112	.71305	29
32	.64989	.76003	.65003	.74857	.67602	.73688	.68878	.72497	.70132	.71285	28
33	.65011	.75984	.64984	.74838	.67623	.73669	.68899	.72477	.70153	.71264	27
34	.65033	.75965	.64965	.74818	.67645	.73649	.68920	.72457	.70174	.71243	26
35	.65055	.75946	.64946	.74799	.67666	.73629	.68941	.72437	.70195	.71223	25
36	.65077	.75927	.64927	.74780	.67688	.73610	.68962	.72417	.70215	.71203	24
37	.65099	.75908	.64908	.74760	.67709	.73590	.68983	.72397	.70236	.71183	23
38	.65122	.75889	.64889	.74741	.67730	.73570	.69004	.72377	.70257	.71162	22
39	.65144	.75870	.64870	.74722	.67752	.73551	.69025	.72357	.70277	.71142	21
40	.65166	.75851	.64850	.74703	.67773	.73531	.69046	.72337	.70298	.71121	20
41	.65188	.75832	.64831	.74683	.67795	.73511	.69067	.72317	.70319	.71100	19
42	.65210	.75813	.64812	.74664	.67816	.73491	.69088	.72297	.70339	.71080	18
43	.65232	.75794	.64793	.74644	.67837	.73472	.69109	.72277	.70360	.71059	17
44	.65254	.75775	.64774	.74625	.67858	.73452	.69130	.72257	.70381	.71039	16
45	.65276	.75756	.64755	.74606	.67878	.73432	.69151	.72237	.70401	.71019	15
46	.65298	.75737	.64736	.74586	.67900	.73413	.69172	.72216	.70422	.70998	14
47	.65320	.75717	.64717	.74567	.67921	.73393	.69193	.72196	.70443	.70978	13
48	.65342	.75698	.64698	.74548	.67942	.73373	.69214	.72176	.70463	.70957	12
49	.65364	.75680	.64679	.74528	.67963	.73353	.69235	.72156	.70484	.70937	11
50	.65386	.75661	.64660	.74509	.67987	.73333	.69256	.72136	.70505	.70916	10
51	.65408	.75642	.64641	.74489	.68008	.73314	.69277	.72116	.70525	.70896	9
52	.65430	.75623	.64622	.74470	.68029	.73294	.69298	.72095	.70546	.70875	8
53	.65452	.75604	.64603	.74451	.68051	.73274	.69319	.72075	.70567	.70855	7
54	.65474	.75585	.64584	.74431	.68072	.73254	.69340	.72055	.70587	.70834	6
55	.65496	.75566	.64565	.74412	.68093	.73234	.69361	.72035	.70608	.70813	5
56	.65518	.75547	.64546	.74392	.68115	.73215	.69382	.72015	.70628	.70793	4
57	.65540	.75528	.64527	.74373	.68136	.73195	.69403	.71995	.70649	.70772	3
58	.65562	.75509	.64508	.74353	.68157	.73175	.69424	.71974	.70670	.70752	2
59	.65584	.75490	.64489	.74334	.68179	.73155	.69445	.71954	.70690	.70731	1
60	.65606	.75471	.64470	.74314	.68200	.73135	.69466	.71934	.70711	.70711	0
°	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	Cosine	Sine	°
	49°		48°		47°		46°		45°		

1	0°		1°		2°		3°		4°		1
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.00000	Infin.	.01746	57.3900	.03492	28.6363	.05241	10.0811	.06993	14.3007	60
1	.00009	3437.75	.01775	56.3506	.03521	28.3904	.05270	10.0755	.07022	14.2411	59
2	.00018	1718.87	.01804	55.4411	.03550	28.1664	.05300	10.0711	.07051	14.1825	58
3	.00027	1145.92	.01833	54.5613	.03579	27.9372	.05328	10.0678	.07080	14.1231	57
4	.00036	859.436	.01862	53.7086	.03606	27.7117	.05357	10.0656	.07110	14.0655	56
5	.00045	687.549	.01891	52.8821	.03638	27.4890	.05387	10.0645	.07139	14.0079	55
6	.00053	572.957	.01920	52.0807	.03667	27.2715	.05416	10.0645	.07168	13.9507	54
7	.00062	491.106	.01949	51.3032	.03696	27.0566	.05445	10.0655	.07197	13.8940	53
8	.00071	429.718	.01978	50.5485	.03725	26.8450	.05474	10.0677	.07227	13.8378	52
9	.00080	381.971	.02007	49.8157	.03754	26.6367	.05503	10.0708	.07256	13.7821	51
10	.00089	343.774	.02036	49.1039	.03783	26.4316	.05533	10.0750	.07285	13.7267	50
11	.00098	312.521	.02066	48.4121	.03812	26.2296	.05562	10.0804	.07314	13.6719	49
12	.00107	286.478	.02095	47.7305	.03842	26.0307	.05591	10.0863	.07344	13.6174	48
13	.00116	264.441	.02124	47.0853	.03871	25.8348	.05620	10.0927	.07373	13.5634	47
14	.00125	245.552	.02153	46.4489	.03900	25.6418	.05649	10.0995	.07402	13.5098	46
15	.00134	229.182	.02182	45.8204	.03929	25.4517	.05678	10.1066	.07431	13.4566	45
16	.00143	214.858	.02211	45.2261	.03958	25.2644	.05708	10.1140	.07461	13.4039	44
17	.00152	202.201	.02240	44.6386	.03987	25.0798	.05737	10.1217	.07490	13.3515	43
18	.00161	190.984	.02269	44.0661	.04016	24.8978	.05766	10.1297	.07519	13.2996	42
19	.00170	180.032	.02298	43.5081	.04046	24.7185	.05795	10.1378	.07548	13.2480	41
20	.00179	171.885	.02328	42.9641	.04075	24.5418	.05824	10.1463	.07578	13.1969	40
21	.00188	165.700	.02357	42.4335	.04104	24.3675	.05854	10.1551	.07607	13.1461	39
22	.00197	156.259	.02386	41.9158	.04133	24.1957	.05883	10.1640	.07636	13.0958	38
23	.00206	148.465	.02415	41.4106	.04162	24.0263	.05912	10.1730	.07665	13.0458	37
24	.00215	141.327	.02444	40.9174	.04191	23.8593	.05941	10.1821	.07694	12.9962	36
25	.00224	134.750	.02473	40.4358	.04220	23.6945	.05970	10.1913	.07723	12.9469	35
26	.00233	128.210	.02502	39.9655	.04249	23.5321	.05999	10.2006	.07752	12.8981	34
27	.00242	121.721	.02531	39.5050	.04279	23.3718	.06028	10.2100	.07782	12.8496	33
28	.00251	115.274	.02560	39.0568	.04308	23.2137	.06058	10.2195	.07812	12.8014	32
29	.00260	118.540	.02589	38.6177	.04337	23.0577	.06087	10.2291	.07841	12.7536	31
30	.00269	114.589	.02619	38.1885	.04366	22.9038	.06116	10.2399	.07870	12.7062	30
31	.00278	110.824	.02648	37.7686	.04395	22.7510	.06145	10.2502	.07899	12.6591	29
32	.00287	107.426	.02677	37.3579	.04424	22.6020	.06175	10.2602	.07929	12.6124	28
33	.00296	104.171	.02706	36.9560	.04454	22.4541	.06204	10.2700	.07958	12.5660	27
34	.00305	101.107	.02735	36.5627	.04483	22.3081	.06233	10.2800	.07987	12.5199	26
35	.00314	98.219	.02764	36.1776	.04512	22.1640	.06262	10.2900	.08017	12.4742	25
36	.00323	95.4895	.02793	35.8006	.04541	22.0217	.06291	10.3000	.08046	12.4288	24
37	.00332	92.9085	.02822	35.4313	.04570	21.8813	.06321	10.3100	.08075	12.3838	23
38	.00341	90.4633	.02851	35.0695	.04599	21.7420	.06350	10.3200	.08104	12.3390	22
39	.00350	88.1436	.02881	34.7151	.04628	21.6065	.06379	10.3300	.08134	12.2946	21
40	.00359	85.9398	.02910	34.3678	.04658	21.4704	.06408	10.3400	.08163	12.2505	20
41	.00368	83.8435	.02939	34.0273	.04687	21.3366	.06437	10.3500	.08192	12.2067	19
42	.00377	81.8470	.02968	33.6935	.04716	21.2049	.06467	10.3600	.08221	12.1632	18
43	.00386	79.9434	.02997	33.3662	.04745	21.0747	.06496	10.3700	.08251	12.1201	17
44	.00395	78.1263	.03026	33.0452	.04774	20.9460	.06525	10.3800	.08280	12.0776	16
45	.00404	76.3900	.03055	32.7303	.04803	20.8188	.06554	10.3900	.08309	12.0346	15
46	.00413	74.7392	.03084	32.4213	.04833	20.6932	.06584	10.4000	.08339	11.9924	14
47	.00422	73.1390	.03114	32.1181	.04862	20.5691	.06613	10.4100	.08368	11.9503	13
48	.00431	71.5815	.03143	31.8205	.04891	20.4465	.06642	10.4200	.08397	11.9087	12
49	.00440	70.1533	.03172	31.5284	.04920	20.3253	.06671	10.4300	.08427	11.8671	11
50	.00449	68.7501	.03201	31.2416	.04949	20.2056	.06700	10.4400	.08456	11.8262	10
51	.00458	67.4019	.03230	30.9599	.04978	20.0872	.06730	10.4506	.08485	11.7853	9
52	.00467	66.1055	.03259	30.6833	.05007	19.9702	.06759	10.4617	.08514	11.7448	8
53	.00476	64.8580	.03288	30.4116	.05037	19.8546	.06788	10.4723	.08544	11.7045	7
54	.00485	63.6567	.03317	30.1446	.05066	19.7403	.06817	10.4834	.08573	11.6645	6
55	.00494	62.4992	.03346	29.8823	.05095	19.6273	.06847	10.4940	.08602	11.6248	5
56	.00503	61.3862	.03375	29.6245	.05124	19.5151	.06876	10.5046	.08632	11.5853	4
57	.00512	60.3058	.03405	29.3711	.05153	19.4039	.06905	10.5153	.08661	11.5461	3
58	.00521	59.2659	.03434	29.1220	.05182	19.2950	.06934	10.5261	.08690	11.5072	2
59	.00530	58.2612	.03463	28.8771	.05212	19.1879	.06963	10.5367	.08720	11.4685	1
60	.00539	57.2900	.03492	28.6363	.05241	19.0811	.06993	10.5474	.08749	11.4301	0
1	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	1
89°		88°		87°		86°		85°			

	5°		6°		7°		8°		9°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.08749	11.4301	.10510	9.51436	.12278	8.14435	.14054	7.11537	.15838	6.31375	60
1	.08778	11.3919	.10540	9.48781	.12308	8.12481	.14084	7.10038	.15868	6.30189	59
2	.08807	11.3540	.10569	9.46141	.12338	8.10536	.14113	7.08546	.15898	6.29007	58
3	.08837	11.3163	.10599	9.43515	.12367	8.08600	.14143	7.07059	.15928	6.27820	57
4	.08866	11.2789	.10628	9.40904	.12397	8.06674	.14173	7.05579	.15958	6.26655	56
5	.08895	11.2417	.10657	9.38307	.12426	8.04756	.14202	7.04105	.15988	6.25486	55
6	.08925	11.2048	.10687	9.35724	.12456	8.02848	.14232	7.02637	.16017	6.24321	54
7	.08954	11.1681	.10716	9.33155	.12485	8.00948	.14262	7.01174	.16047	6.23160	53
8	.08983	11.1316	.10746	9.30599	.12515	7.99058	.14291	6.99718	.16077	6.22003	52
9	.09013	11.0954	.10775	9.28058	.12544	7.97176	.14321	6.98268	.16107	6.20851	51
10	.09042	11.0594	.10805	9.25530	.12574	7.95302	.14351	6.96833	.16137	6.19703	50
11	.09071	11.0237	.10834	9.23016	.12603	7.93438	.14381	6.95385	.16167	6.18550	49
12	.09101	10.9882	.10863	9.20516	.12633	7.91582	.14410	6.93952	.16196	6.17419	48
13	.09130	10.9529	.10893	9.18028	.12662	7.89734	.14440	6.92525	.16226	6.16283	47
14	.09159	10.9178	.10922	9.15554	.12692	7.87895	.14470	6.91104	.16256	6.15151	46
15	.09189	10.8829	.10952	9.13093	.12722	7.86064	.14499	6.89688	.16286	6.14023	45
16	.09218	10.8483	.10981	9.10646	.12751	7.84242	.14529	6.88278	.16316	6.12899	44
17	.09247	10.8139	.11011	9.08211	.12781	7.82428	.14559	6.86874	.16346	6.11779	43
18	.09277	10.7797	.11040	9.05789	.12810	7.80622	.14588	6.85475	.16376	6.10664	42
19	.09306	10.7457	.11070	9.03379	.12840	7.78825	.14618	6.84082	.16405	6.09552	41
20	.09335	10.7119	.11099	9.00983	.12869	7.77035	.14648	6.82694	.16435	6.08444	40
21	.09365	10.6783	.11128	8.98598	.12899	7.75254	.14678	6.81312	.16465	6.07340	39
22	.09394	10.6450	.11158	8.96227	.12929	7.73480	.14707	6.79936	.16495	6.06240	38
23	.09423	10.6118	.11187	8.93867	.12958	7.71715	.14737	6.78564	.16525	6.05143	37
24	.09453	10.5789	.11217	8.91520	.12988	7.69957	.14767	6.77190	.16555	6.04051	36
25	.09482	10.5462	.11246	8.89185	.13017	7.68208	.14796	6.75838	.16585	6.02962	35
26	.09511	10.5136	.11276	8.86862	.13047	7.66466	.14826	6.74483	.16615	6.01878	34
27	.09541	10.4813	.11305	8.84551	.13076	7.64732	.14856	6.73133	.16645	6.00797	33
28	.09570	10.4491	.11335	8.82252	.13106	7.63005	.14886	6.71780	.16674	5.99720	32
29	.09600	10.4172	.11364	8.79964	.13136	7.61287	.14915	6.70450	.16704	5.98646	31
30	.09629	10.3854	.11394	8.77689	.13165	7.59575	.14945	6.69116	.16734	5.97576	30
31	.09658	10.3538	.11423	8.75425	.13195	7.57872	.14975	6.67787	.16764	5.96510	29
32	.09688	10.3224	.11452	8.73172	.13224	7.56176	.15005	6.66463	.16794	5.95448	28
33	.09717	10.2913	.11482	8.70931	.13254	7.54487	.15034	6.65144	.16824	5.94390	27
34	.09746	10.2602	.11511	8.68701	.13284	7.52806	.15064	6.63831	.16854	5.93335	26
35	.09776	10.2294	.11541	8.66482	.13313	7.51132	.15094	6.62523	.16884	5.92283	25
36	.09805	10.1988	.11570	8.64275	.13343	7.49465	.15124	6.61219	.16914	5.91236	24
37	.09834	10.1683	.11600	8.62078	.13372	7.47806	.15153	6.59921	.16944	5.90191	23
38	.09864	10.1381	.11629	8.59893	.13402	7.46154	.15183	6.58627	.16974	5.89151	22
39	.09893	10.1080	.11659	8.57718	.13432	7.44509	.15213	6.57339	.17004	5.88114	21
40	.09923	10.0780	.11688	8.55555	.13461	7.42871	.15243	6.56055	.17033	5.87080	20
41	.09952	10.0483	.11718	8.53402	.13491	7.41240	.15272	6.54777	.17063	5.86051	19
42	.09981	10.0187	.11747	8.51259	.13521	7.39616	.15302	6.53503	.17093	5.85024	18
43	.10011	9.98931	.11777	8.49128	.13550	7.37999	.15332	6.52234	.17123	5.84001	17
44	.10040	9.96007	.11806	8.47007	.13580	7.36380	.15362	6.50970	.17153	5.82982	16
45	.10069	9.93101	.11836	8.44896	.13609	7.34786	.15391	6.49710	.17183	5.81966	15
46	.10099	9.90211	.11865	8.42795	.13639	7.33190	.15421	6.48456	.17213	5.80953	14
47	.10128	9.87338	.11895	8.40705	.13669	7.31600	.15451	6.47206	.17243	5.79944	13
48	.10158	9.84482	.11924	8.38625	.13698	7.30018	.15481	6.45961	.17273	5.78938	12
49	.10187	9.81641	.11954	8.36555	.13728	7.28442	.15511	6.44720	.17303	5.77936	11
50	.10216	9.78817	.11983	8.34496	.13758	7.26873	.15540	6.43484	.17333	5.76937	10
51	.10246	9.76000	.12013	8.32446	.13787	7.25310	.15570	6.42253	.17363	5.75941	9
52	.10275	9.73217	.12042	8.30406	.13817	7.23754	.15600	6.41026	.17393	5.74949	8
53	.10305	9.70441	.12072	8.28376	.13846	7.22204	.15630	6.39804	.17423	5.73960	7
54	.10334	9.67680	.12101	8.26355	.13876	7.20661	.15660	6.38587	.17453	5.72974	6
55	.10363	9.64935	.12131	8.24345	.13906	7.19125	.15689	6.37374	.17483	5.71992	5
56	.10393	9.62205	.12160	8.22344	.13935	7.17594	.15719	6.36165	.17513	5.71013	4
57	.10422	9.59490	.12190	8.20352	.13965	7.16071	.15749	6.34961	.17543	5.70037	3
58	.10452	9.56791	.12219	8.18370	.13995	7.14553	.15779	6.33761	.17573	5.69064	2
59	.10481	9.54101	.12249	8.16398	.14024	7.13042	.15809	6.32566	.17603	5.68094	1
60	.10510	9.51436	.12278	8.14435	.14054	7.11537	.15838	6.31375	.17633	5.67128	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	84°		83°		82°		81°		80°		

	10°		11°		12°		13°		14°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.17633	5.67128	.19438	5.14455	.21256	4.70463	.23087	4.33148	.24933	4.01078	60
1	.17663	5.66165	.19468	5.13658	.21286	4.69791	.23117	4.32573	.24964	4.00582	59
2	.17693	5.65205	.19498	5.12862	.21316	4.69121	.23148	4.32001	.24995	4.00086	58
3	.17723	5.64248	.19529	5.12069	.21347	4.68452	.23179	4.31430	.25026	3.99592	57
4	.17753	5.63295	.19559	5.11279	.21377	4.67786	.23209	4.30860	.25056	3.99099	56
5	.17783	5.62344	.19589	5.10490	.21408	4.67121	.23240	4.30291	.25087	3.98607	55
6	.17813	5.61397	.19619	5.09704	.21438	4.66458	.23271	4.29724	.25118	3.98117	54
7	.17843	5.60452	.19649	5.08921	.21469	4.65797	.23301	4.29159	.25149	3.97627	53
8	.17873	5.59511	.19680	5.08139	.21499	4.65138	.23332	4.28595	.25180	3.97139	52
9	.17903	5.58573	.19710	5.07360	.21529	4.64480	.23363	4.28032	.25211	3.96651	51
10	.17933	5.57638	.19740	5.06584	.21560	4.63825	.23393	4.27471	.25242	3.96165	50
11	.17963	5.56706	.19770	5.05809	.21590	4.63171	.23424	4.26911	.25273	3.95680	49
12	.17993	5.55777	.19801	5.05037	.21621	4.62518	.23455	4.26352	.25304	3.95196	48
13	.18023	5.54851	.19831	5.04267	.21651	4.61868	.23485	4.25795	.25335	3.94713	47
14	.18053	5.53927	.19861	5.03499	.21682	4.61219	.23516	4.25239	.25366	3.94232	46
15	.18083	5.53007	.19891	5.02734	.21712	4.60572	.23547	4.24685	.25397	3.93751	45
16	.18113	5.52090	.19921	5.01971	.21743	4.59927	.23578	4.24132	.25428	3.93271	44
17	.18143	5.51176	.19952	5.01210	.21773	4.59283	.23608	4.23580	.25459	3.92793	43
18	.18173	5.50264	.19982	5.00451	.21804	4.58641	.23639	4.23030	.25490	3.92316	42
19	.18203	5.49356	.20012	4.99695	.21834	4.58001	.23670	4.22481	.25521	3.91839	41
20	.18233	5.48451	.20042	4.98940	.21864	4.57363	.23700	4.21933	.25552	3.91364	40
21	.18263	5.47548	.20073	4.98188	.21895	4.56726	.23731	4.21387	.25583	3.90890	39
22	.18293	5.46648	.20103	4.97438	.21925	4.56091	.23762	4.20842	.25614	3.90417	38
23	.18323	5.45751	.20133	4.96690	.21956	4.55458	.23793	4.20298	.25645	3.89945	37
24	.18353	5.44857	.20164	4.95945	.21986	4.54826	.23823	4.19756	.25676	3.89474	36
25	.18384	5.43966	.20194	4.95201	.22017	4.54196	.23854	4.19215	.25707	3.89004	35
26	.18414	5.43077	.20224	4.94460	.22047	4.53568	.23885	4.18675	.25738	3.88536	34
27	.18444	5.42192	.20254	4.93721	.22078	4.52941	.23916	4.18137	.25769	3.88068	33
28	.18474	5.41309	.20285	4.92984	.22108	4.52316	.23946	4.17600	.25800	3.87601	32
29	.18504	5.40429	.20315	4.92249	.22139	4.51693	.23977	4.17064	.25831	3.87136	31
30	.18534	5.39552	.20345	4.91516	.22169	4.51071	.24008	4.16530	.25862	3.86671	30
31	.18564	5.38677	.20376	4.90785	.22200	4.50451	.24039	4.15997	.25893	3.86208	29
32	.18594	5.37805	.20406	4.90056	.22231	4.49832	.24069	4.15465	.25924	3.85745	28
33	.18624	5.36936	.20436	4.89330	.22261	4.49215	.24100	4.14934	.25955	3.85284	27
34	.18654	5.36070	.20466	4.88605	.22292	4.48600	.24131	4.14405	.25986	3.84824	26
35	.18684	5.35206	.20497	4.87882	.22322	4.47986	.24162	4.13877	.26017	3.84364	25
36	.18714	5.34345	.20527	4.87162	.22353	4.47374	.24193	4.13350	.26048	3.83906	24
37	.18745	5.33487	.20557	4.86444	.22383	4.46764	.24223	4.12825	.26079	3.83449	23
38	.18775	5.32631	.20588	4.85727	.22414	4.46155	.24254	4.12301	.26110	3.82992	22
39	.18805	5.31778	.20618	4.85013	.22444	4.45548	.24285	4.11778	.26141	3.82537	21
40	.18835	5.30928	.20648	4.84300	.22475	4.44942	.24316	4.11256	.26172	3.82083	20
41	.18865	5.30080	.20679	4.83590	.22505	4.44338	.24347	4.10736	.26203	3.81630	19
42	.18895	5.29235	.20709	4.82882	.22536	4.43735	.24377	4.10216	.26235	3.81177	18
43	.18925	5.28393	.20739	4.82175	.22567	4.43134	.24408	4.09696	.26266	3.80726	17
44	.18955	5.27553	.20770	4.81471	.22597	4.42534	.24439	4.09182	.26297	3.80276	16
45	.18986	5.26715	.20800	4.80769	.22628	4.41936	.24470	4.08666	.26328	3.79827	15
46	.19016	5.25880	.20830	4.80068	.22658	4.41340	.24501	4.08152	.26359	3.79378	14
47	.19046	5.25048	.20861	4.79370	.22689	4.40745	.24532	4.07639	.26390	3.78931	13
48	.19076	5.24218	.20891	4.78673	.22719	4.40152	.24562	4.07127	.26421	3.78485	12
49	.19106	5.23391	.20921	4.77978	.22750	4.39560	.24593	4.06616	.26452	3.78040	11
50	.19136	5.22566	.20952	4.77286	.22781	4.38969	.24624	4.06107	.26483	3.77595	10
51	.19166	5.21744	.20982	4.76595	.22811	4.38381	.24655	4.05599	.26515	3.77152	9
52	.19197	5.20925	.21013	4.75906	.22842	4.37793	.24686	4.05092	.26546	3.76709	8
53	.19227	5.20107	.21043	4.75219	.22872	4.37207	.24717	4.04586	.26577	3.76268	7
54	.19257	5.19293	.21073	4.74534	.22903	4.36623	.24747	4.04081	.26608	3.75828	6
55	.19287	5.18480	.21104	4.73851	.22934	4.36040	.24778	4.03578	.26639	3.75388	5
56	.19317	5.17671	.21134	4.73170	.22964	4.35459	.24809	4.03076	.26670	3.74950	4
57	.19347	5.16863	.21164	4.72490	.22995	4.34879	.24840	4.02574	.26701	3.74512	3
58	.19377	5.16058	.21195	4.71813	.23026	4.34300	.24871	4.02074	.26733	3.74073	2
59	.19408	5.15256	.21225	4.71137	.23056	4.33723	.24902	4.01571	.26764	3.73636	1
60	.19438	5.14455	.21256	4.70463	.23087	4.33148	.24933	4.01078	.26795	3.73205	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	79°		78°		77°		76°		75°		

	15°		16°		17°		18°		19°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.26795	3.73205	.28675	3.48741	.30573	3.27085	.32492	3.07768	.34433	2.90421	60
1	.26826	3.72771	.28706	3.48359	.30605	3.26745	.32524	3.07464	.34465	2.90147	59
2	.26857	3.72338	.28738	3.47977	.30637	3.26406	.32556	3.07160	.34498	2.89873	58
3	.26888	3.71907	.28769	3.47596	.30669	3.26067	.32588	3.06857	.34530	2.89600	57
4	.26920	3.71476	.28800	3.47216	.30700	3.25729	.32621	3.06554	.34563	2.89327	56
5	.26951	3.71046	.28832	3.46837	.30732	3.25392	.32653	3.06252	.34596	2.89055	55
6	.26982	3.70616	.28864	3.46458	.30764	3.25055	.32685	3.05950	.34628	2.88783	54
7	.27013	3.70188	.28895	3.46080	.30796	3.24719	.32717	3.05649	.34661	2.88511	53
8	.27044	3.69761	.28927	3.45703	.30828	3.24383	.32749	3.05349	.34693	2.88240	52
9	.27076	3.69335	.28958	3.45327	.30860	3.24049	.32782	3.05049	.34726	2.87970	51
10	.27107	3.68909	.28990	3.44951	.30891	3.23714	.32814	3.04749	.34758	2.87700	50
11	.27138	3.68485	.29021	3.44576	.30923	3.23381	.32846	3.04450	.34791	2.87430	49
12	.27169	3.68061	.29053	3.44202	.30955	3.23048	.32878	3.04152	.34824	2.87161	48
13	.27201	3.67638	.29084	3.43829	.30987	3.22715	.32911	3.03854	.34856	2.86892	47
14	.27232	3.67217	.29116	3.43456	.31019	3.22384	.32943	3.03556	.34889	2.86624	46
15	.27263	3.66796	.29147	3.43084	.31051	3.22053	.32975	3.03260	.34922	2.86356	45
16	.27294	3.66376	.29179	3.42713	.31083	3.21722	.33007	3.02963	.34954	2.86089	44
17	.27326	3.65957	.29210	3.42343	.31115	3.21392	.33040	3.02667	.34987	2.85822	43
18	.27357	3.65538	.29242	3.41973	.31147	3.21063	.33072	3.02372	.35020	2.85555	42
19	.27388	3.65121	.29274	3.41604	.31178	3.20734	.33104	3.02077	.35052	2.85289	41
20	.27419	3.64705	.29305	3.41236	.31210	3.20406	.33136	3.01783	.35085	2.85023	40
21	.27451	3.64289	.29337	3.40869	.31242	3.20079	.33169	3.01489	.35118	2.84758	39
22	.27482	3.63874	.29368	3.40502	.31274	3.19752	.33201	3.01196	.35150	2.84494	38
23	.27513	3.63461	.29400	3.40136	.31306	3.19426	.33233	3.00903	.35183	2.84229	37
24	.27545	3.63048	.29432	3.39771	.31338	3.19100	.33266	3.00611	.35216	2.83965	36
25	.27576	3.62636	.29463	3.39406	.31370	3.18775	.33298	3.00319	.35248	2.83702	35
26	.27607	3.62224	.29495	3.39042	.31402	3.18451	.33330	3.00028	.35281	2.83439	34
27	.27638	3.61814	.29526	3.38679	.31434	3.18127	.33363	3.00737	.35314	2.83176	33
28	.27670	3.61405	.29558	3.38317	.31466	3.17804	.33395	3.00447	.35346	2.82914	32
29	.27701	3.60996	.29590	3.37955	.31498	3.17481	.33427	3.00158	.35379	2.82653	31
30	.27732	3.60588	.29621	3.37594	.31530	3.17159	.33460	3.00868	.35412	2.82391	30
31	.27764	3.60181	.29653	3.37234	.31562	3.16838	.33492	3.00580	.35445	2.82130	29
32	.27795	3.59775	.29685	3.36875	.31594	3.16517	.33524	3.00292	.35477	2.81870	28
33	.27826	3.59370	.29716	3.36516	.31626	3.16197	.33557	3.00004	.35510	2.81610	27
34	.27858	3.58966	.29748	3.36158	.31658	3.15877	.33589	3.00717	.35543	2.81350	26
35	.27889	3.58562	.29780	3.35800	.31690	3.15558	.33621	3.00430	.35576	2.81091	25
36	.27921	3.58160	.29811	3.35443	.31722	3.15240	.33654	3.00144	.35608	2.80833	24
37	.27952	3.57758	.29843	3.35087	.31754	3.14922	.33686	3.00858	.35641	2.80574	23
38	.27983	3.57357	.29875	3.34732	.31786	3.14605	.33718	3.00573	.35674	2.80316	22
39	.28015	3.56957	.29906	3.34377	.31818	3.14288	.33751	3.00288	.35707	2.80059	21
40	.28046	3.56557	.29938	3.34023	.31850	3.13972	.33783	3.00004	.35740	2.79802	20
41	.28077	3.56159	.29970	3.33670	.31882	3.13656	.33816	3.00721	.35772	2.79545	19
42	.28109	3.55761	.30001	3.33317	.31914	3.13341	.33848	3.00437	.35805	2.79289	18
43	.28140	3.55364	.30033	3.32965	.31946	3.13027	.33881	3.00155	.35838	2.79033	17
44	.28172	3.54968	.30065	3.32614	.31978	3.12713	.33913	3.00872	.35871	2.78778	16
45	.28203	3.54573	.30097	3.32264	.32010	3.12400	.33945	3.00591	.35904	2.78523	15
46	.28234	3.54179	.30128	3.31914	.32042	3.12087	.33978	3.00309	.35937	2.78269	14
47	.28266	3.53785	.30160	3.31565	.32074	3.11775	.34010	3.00028	.35969	2.78014	13
48	.28297	3.53393	.30192	3.31216	.32106	3.11464	.34043	3.00748	.36002	2.77761	12
49	.28329	3.53001	.30224	3.30868	.32139	3.11153	.34075	3.00468	.36035	2.77507	11
50	.28360	3.52609	.30255	3.30521	.32171	3.10842	.34108	3.00189	.36068	2.77254	10
51	.28391	3.52219	.30287	3.30174	.32203	3.10532	.34140	3.00909	.36101	2.77002	9
52	.28423	3.51829	.30319	3.29829	.32235	3.10223	.34173	3.00629	.36134	2.76750	8
53	.28454	3.51441	.30351	3.29483	.32267	3.09914	.34205	3.00349	.36167	2.76498	7
54	.28486	3.51053	.30382	3.29139	.32299	3.09606	.34238	3.00070	.36199	2.76247	6
55	.28517	3.50666	.30414	3.28795	.32331	3.09298	.34270	3.00790	.36232	2.75996	5
56	.28549	3.50279	.30446	3.28452	.32363	3.08991	.34303	3.00512	.36265	2.75746	4
57	.28580	3.49894	.30478	3.28109	.32396	3.08685	.34335	3.00234	.36298	2.75496	3
58	.28612	3.49509	.30509	3.27767	.32428	3.08379	.34368	3.00957	.36331	2.75246	2
59	.28643	3.49125	.30541	3.27426	.32460	3.08073	.34400	3.00680	.36364	2.74997	1
60	.28675	3.48741	.30573	3.27085	.32492	3.07768	.34433	3.00402	.36397	2.74748	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	74°		73°		72°		71°		70°		

	20°		21°		22°		23°		24°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.36397	2.74748	.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	60
1	.36430	2.74499	.38420	2.60283	.40436	2.47302	.42482	2.35395	.44558	2.24428	59
2	.36463	2.74251	.38453	2.60057	.40470	2.47095	.42516	2.35205	.44593	2.24252	58
3	.36496	2.74004	.38487	2.59831	.40504	2.46888	.42551	2.35015	.44627	2.24077	57
4	.36529	2.73756	.38520	2.59606	.40538	2.46682	.42585	2.34825	.44662	2.23902	56
5	.36562	2.73509	.38553	2.59381	.40572	2.46476	.42619	2.34636	.44697	2.23727	55
6	.36595	2.73263	.38587	2.59156	.40606	2.46270	.42654	2.34447	.44732	2.23551	54
7	.36628	2.73017	.38620	2.58932	.40640	2.46065	.42688	2.34258	.44767	2.23378	53
8	.36661	2.72771	.38654	2.58708	.40674	2.45860	.42722	2.34069	.44802	2.23204	52
9	.36694	2.72526	.38687	2.58484	.40707	2.45655	.42757	2.33881	.44837	2.23030	51
10	.36727	2.72281	.38721	2.58261	.40741	2.45451	.42791	2.33693	.44872	2.22857	50
11	.36760	2.72036	.38754	2.58038	.40775	2.45246	.42826	2.33505	.44907	2.22683	49
12	.36793	2.71792	.38787	2.57815	.40809	2.45043	.42860	2.33317	.44942	2.22510	48
13	.36826	2.71548	.38821	2.57593	.40843	2.44839	.42894	2.33130	.44977	2.22337	47
14	.36859	2.71305	.38854	2.57371	.40877	2.44636	.42929	2.32943	.45012	2.22164	46
15	.36892	2.71062	.38888	2.57150	.40911	2.44433	.42963	2.32756	.45047	2.21992	45
16	.36925	2.70819	.38921	2.56928	.40945	2.44230	.42998	2.32570	.45082	2.21819	44
17	.36958	2.70575	.38955	2.56707	.40979	2.44027	.43032	2.32383	.45117	2.21647	43
18	.36991	2.70335	.38988	2.56487	.41013	2.43825	.43067	2.32197	.45152	2.21475	42
19	.37024	2.70094	.39022	2.56266	.41047	2.43623	.43101	2.32012	.45187	2.21304	41
20	.37057	2.69853	.39055	2.56046	.41081	2.43422	.43136	2.31826	.45222	2.21132	40
21	.37090	2.69612	.39089	2.55827	.41115	2.43220	.43170	2.31641	.45257	2.20961	39
22	.37123	2.69371	.39122	2.55608	.41149	2.43019	.43205	2.31456	.45292	2.20790	38
23	.37157	2.69131	.39156	2.55389	.41183	2.42819	.43239	2.31271	.45327	2.20619	37
24	.37190	2.68892	.39190	2.55170	.41217	2.42618	.43274	2.31086	.45362	2.20449	36
25	.37223	2.68653	.39223	2.54952	.41251	2.42418	.43308	2.30902	.45397	2.20278	35
26	.37256	2.68414	.39257	2.54734	.41285	2.42218	.43343	2.30718	.45432	2.20108	34
27	.37289	2.68175	.39290	2.54516	.41319	2.42019	.43378	2.30534	.45467	2.19938	33
28	.37322	2.67937	.39324	2.54299	.41353	2.41819	.43412	2.30351	.45502	2.19769	32
29	.37355	2.67700	.39357	2.54082	.41387	2.41620	.43447	2.30167	.45537	2.19599	31
30	.37388	2.67462	.39391	2.53865	.41421	2.41421	.43481	2.29984	.45573	2.19430	30
31	.37422	2.67225	.39425	2.53648	.41455	2.41223	.43516	2.29801	.45608	2.19261	29
32	.37455	2.66989	.39458	2.53432	.41490	2.41025	.43550	2.29619	.45643	2.19092	28
33	.37488	2.66752	.39492	2.53217	.41524	2.40827	.43585	2.29437	.45678	2.18923	27
34	.37521	2.66516	.39526	2.53001	.41558	2.40629	.43620	2.29254	.45713	2.18755	26
35	.37554	2.66281	.39559	2.52786	.41592	2.40432	.43654	2.29073	.45748	2.18587	25
36	.37588	2.66046	.39593	2.52571	.41626	2.40235	.43689	2.28891	.45784	2.18419	24
37	.37621	2.65811	.39626	2.52357	.41660	2.40038	.43724	2.28710	.45819	2.18251	23
38	.37654	2.65576	.39660	2.52142	.41694	2.39841	.43758	2.28528	.45854	2.18084	22
39	.37687	2.65342	.39694	2.51929	.41728	2.39645	.43793	2.28348	.45889	2.17916	21
40	.37720	2.65109	.39727	2.51715	.41763	2.39449	.43828	2.28167	.45924	2.17749	20
41	.37754	2.64875	.39761	2.51502	.41797	2.39253	.43862	2.27987	.45960	2.17582	19
42	.37787	2.64642	.39795	2.51289	.41831	2.39058	.43897	2.27806	.45995	2.17416	18
43	.37820	2.64410	.39829	2.51076	.41865	2.38863	.43932	2.27626	.46030	2.17249	17
44	.37853	2.64177	.39862	2.50864	.41899	2.38668	.43966	2.27447	.46065	2.17083	16
45	.37887	2.63945	.39896	2.50652	.41933	2.38473	.44001	2.27267	.46101	2.16917	15
46	.37920	2.63714	.39930	2.50440	.41968	2.38279	.44036	2.27088	.46136	2.16751	14
47	.37953	2.63483	.39963	2.50229	.42002	2.38084	.44071	2.26909	.46171	2.16585	13
48	.37986	2.63252	.39997	2.50018	.42036	2.37891	.44105	2.26730	.46206	2.16420	12
49	.38020	2.63021	.40031	2.49807	.42070	2.37697	.44140	2.26552	.46242	2.16255	11
50	.38053	2.62791	.40065	2.49597	.42105	2.37504	.44175	2.26374	.46277	2.16090	10
51	.38086	2.62561	.40098	2.49386	.42139	2.37311	.44210	2.26196	.46312	2.15925	9
52	.38120	2.62332	.40132	2.49177	.42173	2.37118	.44244	2.26018	.46348	2.15760	8
53	.38153	2.62103	.40166	2.48967	.42207	2.36925	.44279	2.25840	.46383	2.15596	7
54	.38186	2.61874	.40200	2.48758	.42242	2.36733	.44314	2.25662	.46418	2.15432	6
55	.38220	2.61646	.40234	2.48549	.42276	2.36541	.44349	2.25486	.46454	2.15268	5
56	.38253	2.61418	.40267	2.48340	.42310	2.36349	.44384	2.25310	.46489	2.15104	4
57	.38286	2.61190	.40301	2.48132	.42345	2.36158	.44418	2.25132	.46525	2.14940	3
58	.38320	2.60963	.40335	2.47924	.42379	2.35967	.44453	2.24956	.46560	2.14777	2
59	.38353	2.60736	.40369	2.47716	.42414	2.35776	.44488	2.24780	.46595	2.14614	1
60	.38386	2.60509	.40403	2.47509	.42447	2.35585	.44523	2.24604	.46631	2.14451	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	69°		68°		67°		66°		65°		

	30°		31°		32°		33°		34°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.57735	1.73205	.60086	1.66428	.62487	1.60033	.64941	1.53086	.67451	1.48256	60
1	.57774	1.73080	.60126	1.66318	.62527	1.59930	.64982	1.53888	.67493	1.48163	59
2	.57813	1.72973	.60165	1.66209	.62568	1.59826	.65024	1.53791	.67536	1.48070	58
3	.57851	1.72857	.60205	1.66099	.62608	1.59723	.65065	1.53693	.67578	1.47977	57
4	.57890	1.72741	.60245	1.65990	.62649	1.59620	.65106	1.53595	.67620	1.47885	56
5	.57929	1.72625	.60284	1.65881	.62689	1.59517	.65148	1.53497	.67663	1.47792	55
6	.57968	1.72509	.60324	1.65772	.62730	1.59414	.65189	1.53400	.67705	1.47699	54
7	.58007	1.72393	.60364	1.65663	.62770	1.59311	.65231	1.53302	.67748	1.47607	53
8	.58046	1.72278	.60403	1.65554	.62811	1.59208	.65272	1.53205	.67790	1.47514	52
9	.58085	1.72163	.60443	1.65445	.62852	1.59105	.65314	1.53107	.67832	1.47422	51
10	.58124	1.72047	.60483	1.65337	.62892	1.59002	.65355	1.53010	.67875	1.47330	50
11	.58162	1.71932	.60522	1.65228	.62933	1.58900	.65397	1.52913	.67917	1.47238	49
12	.58201	1.71817	.60562	1.65120	.62973	1.58797	.65438	1.52816	.67960	1.47146	48
13	.58240	1.71702	.60602	1.65011	.63014	1.58695	.65480	1.52719	.68002	1.47053	47
14	.58279	1.71588	.60642	1.64903	.63055	1.58593	.65521	1.52622	.68045	1.46962	46
15	.58318	1.71473	.60681	1.64795	.63095	1.58490	.65563	1.52525	.68088	1.46870	45
16	.58357	1.71358	.60721	1.64687	.63136	1.58388	.65604	1.52428	.68130	1.46778	44
17	.58396	1.71244	.60761	1.64579	.63177	1.58286	.65646	1.52332	.68173	1.46686	43
18	.58435	1.71129	.60801	1.64471	.63217	1.58184	.65688	1.52235	.68215	1.46595	42
19	.58474	1.71015	.60841	1.64363	.63258	1.58083	.65729	1.52139	.68258	1.46503	41
20	.58513	1.70901	.60881	1.64256	.63299	1.57981	.65771	1.52043	.68301	1.46411	40
21	.58552	1.70787	.60921	1.64148	.63340	1.57879	.65813	1.51946	.68343	1.46320	39
22	.58591	1.70673	.60960	1.64041	.63380	1.57778	.65854	1.51850	.68386	1.46229	38
23	.58631	1.70560	.61000	1.63934	.63421	1.57676	.65896	1.51754	.68429	1.46137	37
24	.58670	1.70446	.61040	1.63826	.63462	1.57575	.65938	1.51658	.68471	1.46046	36
25	.58709	1.70332	.61080	1.63719	.63503	1.57474	.65980	1.51562	.68514	1.45955	35
26	.58748	1.70219	.61120	1.63612	.63544	1.57372	.66021	1.51466	.68557	1.45864	34
27	.58787	1.70106	.61160	1.63505	.63584	1.57271	.66063	1.51370	.68600	1.45773	33
28	.58826	1.69992	.61200	1.63398	.63625	1.57170	.66105	1.51275	.68642	1.45682	32
29	.58865	1.69879	.61240	1.63292	.63666	1.57069	.66147	1.51179	.68685	1.45592	31
30	.58905	1.69766	.61280	1.63185	.63707	1.56969	.66189	1.51084	.68728	1.45501	30
31	.58944	1.69653	.61320	1.63079	.63748	1.56868	.66230	1.50988	.68771	1.45410	29
32	.58983	1.69541	.61360	1.62972	.63789	1.56767	.66272	1.50893	.68814	1.45320	28
33	.59022	1.69428	.61400	1.62866	.63830	1.56666	.66314	1.50797	.68857	1.45229	27
34	.59061	1.69316	.61440	1.62760	.63871	1.56566	.66356	1.50702	.68900	1.45139	26
35	.59101	1.69203	.61480	1.62654	.63912	1.56466	.66398	1.50607	.68942	1.45050	25
36	.59140	1.69091	.61520	1.62548	.63953	1.56366	.66440	1.50512	.68985	1.44958	24
37	.59179	1.68979	.61561	1.62442	.63994	1.56265	.66482	1.50417	.69028	1.44868	23
38	.59218	1.68866	.61601	1.62336	.64035	1.56165	.66524	1.50322	.69071	1.44778	22
39	.59258	1.68754	.61641	1.62230	.64076	1.56065	.66566	1.50228	.69114	1.44688	21
40	.59297	1.68643	.61681	1.62125	.64117	1.55966	.66608	1.50133	.69157	1.44598	20
41	.59336	1.68531	.61721	1.62019	.64158	1.55866	.66650	1.50038	.69200	1.44508	19
42	.59376	1.68419	.61761	1.61914	.64199	1.55766	.66692	1.49944	.69243	1.44418	18
43	.59415	1.68308	.61801	1.61808	.64240	1.55666	.66734	1.49849	.69286	1.44329	17
44	.59454	1.68196	.61842	1.61703	.64281	1.55567	.66776	1.49755	.69329	1.44239	16
45	.59494	1.68085	.61882	1.61598	.64322	1.55467	.66818	1.49661	.69372	1.44149	15
46	.59533	1.67974	.61922	1.61493	.64363	1.55368	.66860	1.49566	.69416	1.44060	14
47	.59573	1.67863	.61962	1.61388	.64404	1.55269	.66902	1.49472	.69459	1.43970	13
48	.59612	1.67752	.62003	1.61283	.64446	1.55170	.66944	1.49378	.69502	1.43881	12
49	.59651	1.67641	.62043	1.61179	.64487	1.55071	.66986	1.49284	.69545	1.43792	11
50	.59691	1.67530	.62083	1.61074	.64528	1.54972	.67028	1.49190	.69588	1.43703	10
51	.59730	1.67419	.62124	1.60970	.64569	1.54873	.67071	1.49097	.69631	1.43614	9
52	.59770	1.67309	.62164	1.60865	.64610	1.54774	.67113	1.49003	.69675	1.43525	8
53	.59809	1.67198	.62204	1.60761	.64652	1.54675	.67155	1.48909	.69718	1.43436	7
54	.59849	1.67088	.62245	1.60657	.64693	1.54576	.67197	1.48816	.69761	1.43347	6
55	.59888	1.66978	.62285	1.60553	.64734	1.54478	.67239	1.48722	.69804	1.43258	5
56	.59928	1.66867	.62325	1.60449	.64775	1.54379	.67282	1.48629	.69847	1.43169	4
57	.59967	1.66757	.62366	1.60345	.64817	1.54281	.67324	1.48536	.69891	1.43080	3
58	.60007	1.66647	.62406	1.60241	.64858	1.54183	.67366	1.48442	.69934	1.42992	2
59	.60046	1.66538	.62446	1.60137	.64899	1.54085	.67409	1.48349	.69977	1.42903	1
60	.60086	1.66428	.62487	1.60033	.64941	1.53986	.67451	1.48256	.70021	1.42815	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	59°		58°		57°		56°		55°		

NATURAL TANGENTS AND COTANGENTS.

19

	35°		36°		37°		38°		39°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.70021	1.42815	.72654	1.37638	.75355	1.32704	.78129	1.27994	.80978	1.23400	60
1	.70064	1.42726	.72699	1.37554	.75401	1.32624	.78175	1.27917	.81027	1.23416	59
2	.70107	1.42638	.72743	1.37470	.75447	1.32544	.78222	1.27841	.81075	1.23433	58
3	.70151	1.42550	.72788	1.37386	.75492	1.32464	.78269	1.27764	.81123	1.23450	57
4	.70194	1.42462	.72832	1.37302	.75538	1.32384	.78316	1.27688	.81171	1.23467	56
5	.70238	1.42374	.72877	1.37218	.75584	1.32304	.78363	1.27611	.81220	1.23483	55
6	.70281	1.42286	.72921	1.37134	.75629	1.32224	.78410	1.27535	.81268	1.23500	54
7	.70325	1.42198	.72966	1.37050	.75675	1.32144	.78457	1.27458	.81316	1.23517	53
8	.70368	1.42110	.73010	1.36967	.75721	1.32064	.78504	1.27382	.81364	1.23534	52
9	.70412	1.42022	.73055	1.36883	.75767	1.31984	.78551	1.27306	.81413	1.23551	51
10	.70455	1.41934	.73100	1.36800	.75812	1.31904	.78598	1.27230	.81461	1.23568	50
11	.70499	1.41847	.73144	1.36716	.75858	1.31825	.78645	1.27153	.81510	1.23585	49
12	.70542	1.41759	.73189	1.36633	.75904	1.31745	.78692	1.27077	.81558	1.23602	48
13	.70586	1.41672	.73234	1.36549	.75950	1.31666	.78739	1.27001	.81606	1.23619	47
14	.70629	1.41584	.73278	1.36466	.75996	1.31586	.78786	1.26925	.81655	1.23636	46
15	.70673	1.41497	.73323	1.36383	.76042	1.31507	.78834	1.26849	.81703	1.23653	45
16	.70717	1.41409	.73368	1.36300	.76088	1.31427	.78881	1.26774	.81752	1.23670	44
17	.70760	1.41322	.73413	1.36217	.76134	1.31348	.78928	1.26698	.81800	1.23687	43
18	.70804	1.41235	.73457	1.36134	.76180	1.31269	.78975	1.26622	.81849	1.23704	42
19	.70848	1.41148	.73502	1.36051	.76226	1.31190	.79022	1.26546	.81898	1.23721	41
20	.70891	1.41061	.73547	1.35968	.76272	1.31110	.79070	1.26471	.81946	1.23738	40
21	.70935	1.40974	.73592	1.35885	.76318	1.31031	.79117	1.26395	.81995	1.23755	39
22	.70979	1.40887	.73637	1.35802	.76364	1.30952	.79164	1.26319	.82044	1.23772	38
23	.71023	1.40800	.73681	1.35719	.76410	1.30873	.79212	1.26244	.82092	1.23789	37
24	.71066	1.40714	.73726	1.35637	.76456	1.30795	.79259	1.26169	.82141	1.23806	36
25	.71110	1.40627	.73771	1.35554	.76502	1.30716	.79306	1.26093	.82190	1.23823	35
26	.71154	1.40540	.73816	1.35472	.76548	1.30637	.79354	1.26018	.82238	1.23840	34
27	.71198	1.40454	.73861	1.35389	.76594	1.30558	.79401	1.25943	.82287	1.23857	33
28	.71242	1.40367	.73906	1.35307	.76640	1.30480	.79449	1.25867	.82336	1.23874	32
29	.71285	1.40281	.73951	1.35224	.76686	1.30401	.79496	1.25792	.82385	1.23891	31
30	.71329	1.40195	.73996	1.35142	.76733	1.30323	.79544	1.25717	.82434	1.23908	30
31	.71373	1.40109	.74041	1.35060	.76779	1.30244	.79591	1.25642	.82483	1.23925	29
32	.71417	1.40022	.74086	1.34978	.76825	1.30166	.79639	1.25567	.82531	1.23942	28
33	.71461	1.39936	.74131	1.34896	.76871	1.30087	.79686	1.25492	.82580	1.23959	27
34	.71505	1.39850	.74176	1.34814	.76918	1.30009	.79734	1.25417	.82629	1.23976	26
35	.71549	1.39764	.74221	1.34732	.76964	1.29931	.79781	1.25343	.82678	1.23993	25
36	.71593	1.39679	.74267	1.34650	.77010	1.29853	.79829	1.25268	.82727	1.24010	24
37	.71637	1.39593	.74312	1.34568	.77057	1.29775	.79877	1.25193	.82776	1.24027	23
38	.71681	1.39507	.74357	1.34486	.77103	1.29696	.79924	1.25118	.82825	1.24044	22
39	.71725	1.39421	.74402	1.34405	.77149	1.29618	.79972	1.25044	.82874	1.24061	21
40	.71769	1.39336	.74447	1.34323	.77196	1.29541	.80020	1.24969	.82923	1.24078	20
41	.71813	1.39250	.74492	1.34242	.77242	1.29463	.80067	1.24895	.82972	1.24095	19
42	.71857	1.39165	.74538	1.34160	.77289	1.29385	.80115	1.24820	.83021	1.24112	18
43	.71901	1.39079	.74583	1.34079	.77335	1.29307	.80163	1.24746	.83071	1.24129	17
44	.71946	1.38994	.74628	1.33998	.77382	1.29229	.80211	1.24672	.83120	1.24146	16
45	.71990	1.38909	.74674	1.33916	.77428	1.29152	.80258	1.24597	.83169	1.24163	15
46	.72034	1.38824	.74719	1.33835	.77475	1.29074	.80306	1.24523	.83218	1.24180	14
47	.72078	1.38738	.74764	1.33754	.77521	1.28997	.80354	1.24449	.83268	1.24197	13
48	.72122	1.38653	.74810	1.33673	.77568	1.28919	.80402	1.24375	.83317	1.24214	12
49	.72167	1.38568	.74855	1.33592	.77615	1.28842	.80450	1.24301	.83366	1.24231	11
50	.72211	1.38484	.74900	1.33511	.77661	1.28764	.80498	1.24227	.83415	1.24248	10
51	.72255	1.38399	.74946	1.33430	.77708	1.28687	.80546	1.24153	.83465	1.24265	9
52	.72299	1.38314	.74991	1.33349	.77754	1.28610	.80594	1.24079	.83514	1.24282	8
53	.72344	1.38229	.75037	1.33268	.77801	1.28533	.80642	1.24005	.83564	1.24299	7
54	.72388	1.38145	.75082	1.33187	.77848	1.28456	.80690	1.23931	.83613	1.24316	6
55	.72432	1.38060	.75128	1.33107	.77895	1.28379	.80738	1.23858	.83662	1.24333	5
56	.72477	1.37976	.75173	1.33026	.77941	1.28302	.80786	1.23784	.83712	1.24350	4
57	.72521	1.37891	.75219	1.32946	.77988	1.28225	.80834	1.23710	.83761	1.24367	3
58	.72565	1.37807	.75264	1.32865	.78035	1.28148	.80882	1.23637	.83811	1.24384	2
59	.72610	1.37722	.75310	1.32785	.78082	1.28071	.80930	1.23563	.83860	1.24401	1
60	.72654	1.37638	.75355	1.32704	.78129	1.27994	.80978	1.23490	.83910	1.24418	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	54°		53°		52°		51°		50°		

	40°		41°		42°		43°		44°		
	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	
0	.83910	1.19175	.86929	1.15037	.90040	1.11061	.93252	1.07237	.96569	1.03553	60
1	.83960	1.19105	.86980	1.14969	.90093	1.10996	.93306	1.07174	.96625	1.03493	59
2	.84009	1.19035	.87031	1.14902	.90146	1.10931	.93360	1.07112	.96681	1.03433	58
3	.84059	1.18964	.87082	1.14834	.90199	1.10867	.93415	1.07049	.96738	1.03372	57
4	.84108	1.18894	.87133	1.14767	.90251	1.10802	.93469	1.06987	.96794	1.03312	56
5	.84158	1.18824	.87184	1.14699	.90304	1.10737	.93524	1.06925	.96850	1.03252	55
6	.84208	1.18754	.87236	1.14632	.90357	1.10672	.93578	1.06862	.96907	1.03192	54
7	.84258	1.18684	.87287	1.14565	.90410	1.10607	.93633	1.06800	.96963	1.03132	53
8	.84307	1.18614	.87338	1.14498	.90463	1.10543	.93688	1.06738	.97020	1.03072	52
9	.84357	1.18544	.87389	1.14430	.90516	1.10478	.93742	1.06676	.97076	1.03012	51
10	.84407	1.18474	.87441	1.14363	.90569	1.10414	.93797	1.06613	.97133	1.02952	50
11	.84457	1.18404	.87492	1.14296	.90621	1.10349	.93852	1.06551	.97189	1.02892	49
12	.84507	1.18334	.87543	1.14229	.90674	1.10285	.93906	1.06489	.97246	1.02832	48
13	.84556	1.18264	.87595	1.14162	.90727	1.10220	.93961	1.06427	.97302	1.02772	47
14	.84606	1.18194	.87646	1.14095	.90781	1.10156	.94016	1.06365	.97359	1.02713	46
15	.84656	1.18125	.87698	1.14028	.90834	1.10091	.94071	1.06303	.97416	1.02653	45
16	.84706	1.18055	.87749	1.13961	.90887	1.10027	.94125	1.06241	.97472	1.02593	44
17	.84756	1.17986	.87801	1.13894	.90940	1.09963	.94180	1.06179	.97529	1.02533	43
18	.84806	1.17916	.87852	1.13828	.90993	1.09899	.94235	1.06117	.97586	1.02474	42
19	.84856	1.17846	.87904	1.13761	.91046	1.09834	.94290	1.06056	.97643	1.02414	41
20	.84906	1.17777	.87955	1.13694	.91099	1.09770	.94345	1.05994	.97700	1.02355	40
21	.84956	1.17708	.88007	1.13627	.91153	1.09706	.94400	1.05932	.97756	1.02295	39
22	.85006	1.17638	.88059	1.13561	.91206	1.09642	.94455	1.05870	.97813	1.02236	38
23	.85057	1.17569	.88110	1.13494	.91259	1.09578	.94510	1.05809	.97870	1.02176	37
24	.85107	1.17500	.88162	1.13428	.91313	1.09514	.94565	1.05747	.97927	1.02117	36
25	.85157	1.17430	.88214	1.13361	.91366	1.09450	.94620	1.05685	.97984	1.02057	35
26	.85207	1.17361	.88265	1.13295	.91419	1.09386	.94676	1.05624	.98041	1.01998	34
27	.85257	1.17292	.88317	1.13228	.91473	1.09322	.94731	1.05562	.98098	1.01939	33
28	.85308	1.17223	.88369	1.13162	.91526	1.09258	.94786	1.05501	.98155	1.01879	32
29	.85358	1.17154	.88421	1.13096	.91580	1.09195	.94841	1.05439	.98213	1.01820	31
30	.85408	1.17085	.88473	1.13029	.91633	1.09131	.94896	1.05378	.98270	1.01761	30
31	.85458	1.17016	.88524	1.12963	.91687	1.09067	.94952	1.05317	.98327	1.01702	29
32	.85509	1.16947	.88576	1.12897	.91740	1.09003	.95007	1.05255	.98384	1.01642	28
33	.85559	1.16878	.88628	1.12831	.91794	1.08940	.95062	1.05194	.98441	1.01583	27
34	.85609	1.16809	.88680	1.12765	.91847	1.08876	.95118	1.05133	.98499	1.01524	26
35	.85660	1.16741	.88732	1.12699	.91901	1.08813	.95173	1.05072	.98556	1.01465	25
36	.85710	1.16672	.88784	1.12633	.91955	1.08749	.95229	1.05010	.98613	1.01406	24
37	.85761	1.16603	.88836	1.12567	.92008	1.08686	.95284	1.04949	.98671	1.01347	23
38	.85811	1.16535	.88888	1.12501	.92062	1.08622	.95340	1.04888	.98728	1.01288	22
39	.85862	1.16466	.88940	1.12435	.92116	1.08559	.95395	1.04827	.98786	1.01229	21
40	.85912	1.16398	.88992	1.12369	.92170	1.08496	.95451	1.04766	.98843	1.01170	20
41	.85963	1.16329	.89045	1.12303	.92224	1.08432	.95506	1.04705	.98901	1.01112	19
42	.86014	1.16261	.89097	1.12238	.92277	1.08369	.95562	1.04644	.98958	1.01053	18
43	.86064	1.16192	.89149	1.12172	.92331	1.08306	.95618	1.04583	.99016	1.00994	17
44	.86115	1.16124	.89201	1.12106	.92385	1.08243	.95673	1.04522	.99073	1.00935	16
45	.86166	1.16056	.89253	1.12041	.92439	1.08179	.95729	1.04461	.99131	1.00876	15
46	.86216	1.15987	.89306	1.11975	.92493	1.08116	.95785	1.04401	.99189	1.00818	14
47	.86267	1.15919	.89358	1.11909	.92547	1.08053	.95841	1.04340	.99247	1.00759	13
48	.86318	1.15851	.89410	1.11844	.92601	1.07990	.95897	1.04279	.99304	1.00701	12
49	.86368	1.15783	.89463	1.11778	.92655	1.07927	.95952	1.04218	.99362	1.00642	11
50	.86419	1.15715	.89515	1.11713	.92709	1.07864	.96008	1.04158	.99420	1.00583	10
51	.86470	1.15647	.89567	1.11648	.92763	1.07801	.96064	1.04097	.99478	1.00525	9
52	.86521	1.15579	.89620	1.11582	.92817	1.07738	.96120	1.04036	.99536	1.00467	8
53	.86572	1.15511	.89672	1.11517	.92872	1.07676	.96176	1.03976	.99594	1.00408	7
54	.86623	1.15443	.89725	1.11452	.92926	1.07613	.96232	1.03915	.99652	1.00350	6
55	.86674	1.15375	.89777	1.11387	.92980	1.07550	.96288	1.03855	.99710	1.00291	5
56	.86725	1.15308	.89830	1.11321	.93034	1.07487	.96344	1.03794	.99768	1.00233	4
57	.86776	1.15240	.89883	1.11256	.93088	1.07425	.96400	1.03734	.99826	1.00175	3
58	.86827	1.15172	.89935	1.11191	.93143	1.07362	.96457	1.03673	.99884	1.00116	2
59	.86878	1.15104	.89988	1.11126	.93197	1.07299	.96513	1.03613	.99942	1.00058	1
60	.86929	1.15037	.90040	1.11061	.93252	1.07237	.96569	1.03553	1.00000	1.00000	0
	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	Cotang	Tang	
	49°		48°		47°		46°		45°		

TRAVERSE TABLES
OR
LATITUDES AND DEPARTURES OF COURSES
CALCULATED TO
THREE DECIMAL PLACES
FOR
EACH QUARTER DEGREE OF BEARING.

LATITUDES AND DEPARTURES.

23

Bearing.	1		2		3		4		5	Bearing.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
0°	1.000	0.000	2.000	0.000	3.000	0.000	4.000	0.000	5.000	90°
0 1/4	1.000	0.004	2.000	0.009	3.000	0.013	4.000	0.017	5.000	89 3/4
0 1/2	1.000	0.009	2.000	0.017	3.000	0.026	4.000	0.035	5.000	89 1/2
0 3/4	1.000	0.013	2.000	0.026	3.000	0.039	4.000	0.052	5.000	89 1/4
1°	1.000	0.017	2.000	0.035	3.000	0.052	3.999	0.070	4.999	89°
1 1/4	1.000	0.022	2.000	0.044	2.999	0.065	3.999	0.087	4.999	88 3/4
1 1/2	1.000	0.026	1.999	0.052	2.999	0.079	3.999	0.105	4.998	88 1/2
1 3/4	1.000	0.031	1.999	0.061	2.999	0.092	3.998	0.122	4.998	88 1/4
2°	0.999	0.035	1.999	0.070	2.998	0.105	3.998	0.140	4.997	88°
2 1/4	0.999	0.039	1.998	0.079	2.998	0.118	3.997	0.157	4.996	87 3/4
2 1/2	0.999	0.044	1.998	0.087	2.997	0.131	3.996	0.174	4.995	87 1/2
2 3/4	0.999	0.048	1.998	0.096	2.997	0.144	3.995	0.192	4.994	87 1/4
3°	0.999	0.052	1.997	0.105	2.996	0.157	3.995	0.209	4.993	87°
3 1/4	0.998	0.057	1.997	0.113	2.995	0.170	3.994	0.227	4.992	86 3/4
3 1/2	0.998	0.061	1.996	0.122	2.994	0.183	3.993	0.244	4.991	86 1/2
3 3/4	0.998	0.065	1.996	0.131	2.994	0.196	3.991	0.262	4.989	86 1/4
4°	0.998	0.070	1.995	0.140	2.993	0.209	3.990	0.279	4.988	86°
4 1/4	0.997	0.074	1.995	0.148	2.992	0.222	3.989	0.296	4.986	85 3/4
4 1/2	0.997	0.078	1.994	0.157	2.991	0.235	3.988	0.314	4.985	85 1/2
4 3/4	0.997	0.083	1.993	0.166	2.990	0.248	3.986	0.331	4.983	85 1/4
5°	0.996	0.087	1.992	0.174	2.989	0.261	3.985	0.349	4.981	85°
5 1/4	0.996	0.092	1.992	0.183	2.987	0.275	3.983	0.366	4.979	84 3/4
5 1/2	0.995	0.096	1.991	0.192	2.986	0.288	3.982	0.383	4.977	84 1/2
5 3/4	0.995	0.100	1.990	0.200	2.985	0.301	3.980	0.401	4.975	84 1/4
6°	0.995	0.105	1.989	0.209	2.984	0.314	3.978	0.418	4.973	84°
6 1/4	0.994	0.109	1.988	0.218	2.982	0.327	3.976	0.435	4.970	83 3/4
6 1/2	0.994	0.113	1.987	0.226	2.981	0.340	3.974	0.453	4.968	83 1/2
6 3/4	0.993	0.118	1.986	0.235	2.979	0.353	3.972	0.470	4.965	83 1/4
7°	0.993	0.122	1.985	0.244	2.978	0.366	3.970	0.487	4.963	83°
7 1/4	0.992	0.126	1.984	0.252	2.976	0.379	3.968	0.505	4.960	82 3/4
7 1/2	0.991	0.131	1.983	0.261	2.974	0.392	3.966	0.522	4.957	82 1/2
7 3/4	0.991	0.135	1.982	0.270	2.973	0.405	3.963	0.539	4.954	82 1/4
8°	0.990	0.139	1.981	0.278	2.971	0.418	3.961	0.557	4.951	82°
8 1/4	0.990	0.143	1.979	0.287	2.969	0.430	3.959	0.574	4.948	81 3/4
8 1/2	0.989	0.148	1.978	0.296	2.967	0.443	3.956	0.591	4.945	81 1/2
8 3/4	0.988	0.152	1.977	0.304	2.965	0.456	3.953	0.608	4.942	81 1/4
9°	0.988	0.156	1.975	0.313	2.963	0.469	3.951	0.626	4.938	81°
9 1/4	0.987	0.161	1.974	0.321	2.961	0.482	3.948	0.643	4.935	80 3/4
9 1/2	0.986	0.165	1.973	0.330	2.959	0.495	3.945	0.660	4.931	80 1/2
9 3/4	0.986	0.169	1.971	0.339	2.957	0.508	3.942	0.677	4.928	80 1/4
10°	0.985	0.174	1.970	0.347	2.954	0.521	3.939	0.695	4.924	80°
10 1/4	0.984	0.178	1.968	0.356	2.952	0.534	3.936	0.712	4.920	79 3/4
10 1/2	0.983	0.182	1.967	0.364	2.950	0.547	3.933	0.729	4.916	79 1/2
10 3/4	0.982	0.187	1.965	0.373	2.947	0.560	3.930	0.746	4.912	79 1/4
11°	0.982	0.191	1.963	0.382	2.945	0.572	3.927	0.763	4.908	79°
11 1/4	0.981	0.195	1.962	0.390	2.942	0.585	3.923	0.780	4.904	78 3/4
11 1/2	0.980	0.199	1.960	0.399	2.940	0.598	3.920	0.797	4.900	78 1/2
11 3/4	0.979	0.204	1.958	0.407	2.937	0.611	3.916	0.815	4.895	78 1/4
12°	0.978	0.208	1.956	0.416	2.934	0.624	3.913	0.832	4.891	78°
12 1/4	0.977	0.212	1.954	0.424	2.932	0.637	3.909	0.849	4.886	77 3/4
12 1/2	0.976	0.216	1.953	0.433	2.929	0.649	3.905	0.866	4.881	77 1/2
12 3/4	0.975	0.221	1.951	0.441	2.926	0.662	3.901	0.883	4.877	77 1/4
13°	0.974	0.225	1.949	0.450	2.923	0.675	3.897	0.900	4.872	77°
Bearing.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Bearing.
	1		2		3		4		5	

LATITUDES AND DEPARTURES.

Bearing.	5		6		7		8		9		Bearing.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
0°	0.000	6.000	0.000	7.000	0.000	8.000	0.000	9.000	0.000	90°	
0¼	0.022	6.000	0.026	7.000	0.031	8.000	0.035	9.000	0.039	89¾	
0½	0.044	6.000	0.052	7.000	0.061	8.000	0.070	9.000	0.079	89½	
0¾	0.065	5.999	0.079	6.999	0.092	7.999	0.105	8.999	0.118	89¼	
1°	0.087	5.999	0.105	6.999	0.122	7.999	0.140	8.999	0.157	89°	
1¼	0.109	5.999	0.131	6.998	0.153	7.998	0.175	8.998	0.196	88¾	
1½	0.131	5.998	0.157	6.998	0.183	7.997	0.209	8.997	0.236	88½	
1¾	0.153	5.997	0.183	6.997	0.214	7.996	0.244	8.996	0.275	88¼	
2°	0.174	5.996	0.209	6.996	0.244	7.995	0.279	8.995	0.314	88°	
2¼	0.196	5.995	0.236	6.995	0.275	7.994	0.314	8.993	0.353	87¾	
2½	0.218	5.994	0.262	6.993	0.305	7.992	0.349	8.991	0.393	87½	
2¾	0.240	5.993	0.288	6.992	0.336	7.991	0.384	8.990	0.432	87¼	
3°	0.262	5.992	0.314	6.990	0.366	7.989	0.419	8.988	0.471	87°	
3¼	0.283	5.990	0.340	6.989	0.397	7.987	0.454	8.986	0.510	86¾	
3½	0.305	5.989	0.366	6.987	0.427	7.985	0.488	8.983	0.549	86½	
3¾	0.327	5.987	0.392	6.985	0.458	7.983	0.523	8.981	0.589	86¼	
4°	0.349	5.985	0.419	6.983	0.488	7.981	0.558	8.978	0.628	86°	
4¼	0.371	5.984	0.445	6.981	0.519	7.978	0.593	8.975	0.667	85¾	
4½	0.392	5.982	0.471	6.978	0.549	7.975	0.628	8.972	0.706	85½	
4¾	0.414	5.979	0.497	6.976	0.580	7.973	0.662	8.969	0.745	85¼	
5°	0.436	5.977	0.523	6.973	0.610	7.970	0.697	8.966	0.784	85°	
5¼	0.458	5.975	0.549	6.971	0.641	7.966	0.732	8.962	0.824	84¾	
5½	0.479	5.972	0.575	6.968	0.671	7.963	0.767	8.959	0.863	84½	
5¾	0.501	5.970	0.601	6.965	0.701	7.960	0.802	8.955	0.902	84¼	
6°	0.523	5.967	0.627	6.962	0.732	7.956	0.836	8.951	0.941	84°	
6¼	0.544	5.964	0.653	6.958	0.762	7.952	0.871	8.947	0.980	83¾	
6½	0.566	5.961	0.679	6.955	0.792	7.949	0.906	8.942	1.019	83½	
6¾	0.588	5.958	0.705	6.951	0.823	7.945	0.940	8.938	1.058	83¼	
7°	0.609	5.955	0.731	6.948	0.853	7.940	0.975	8.933	1.097	83°	
7¼	0.631	5.952	0.757	6.944	0.883	7.936	1.010	8.928	1.136	82¾	
7½	0.653	5.949	0.783	6.940	0.914	7.932	1.044	8.923	1.175	82½	
7¾	0.674	5.945	0.809	6.936	0.944	7.927	1.079	8.918	1.214	82¼	
8°	0.696	5.942	0.835	6.932	0.974	7.922	1.113	8.912	1.253	82°	
8¼	0.717	5.938	0.861	6.928	1.004	7.917	1.148	8.907	1.291	81¾	
8½	0.739	5.934	0.887	6.923	1.035	7.912	1.182	8.901	1.330	81½	
8¾	0.761	5.930	0.913	6.919	1.065	7.907	1.217	8.895	1.369	81¼	
9°	0.782	5.926	0.939	6.914	1.095	7.902	1.251	8.889	1.408	81°	
9¼	0.804	5.922	0.964	6.909	1.125	7.896	1.286	8.883	1.447	80¾	
9½	0.825	5.918	0.990	6.904	1.155	7.890	1.320	8.877	1.485	80½	
9¾	0.847	5.913	1.016	6.899	1.185	7.884	1.355	8.870	1.524	80¼	
10°	0.868	5.909	1.042	6.894	1.216	7.878	1.389	8.863	1.563	80°	
10¼	0.890	5.904	1.068	6.888	1.246	7.872	1.424	8.856	1.601	79¾	
10½	0.911	5.900	1.093	6.883	1.276	7.866	1.458	8.849	1.640	79½	
10¾	0.933	5.895	1.119	6.877	1.306	7.860	1.492	8.842	1.679	79¼	
11°	0.954	5.890	1.145	6.871	1.336	7.853	1.526	8.835	1.717	79°	
11¼	0.975	5.885	1.171	6.866	1.366	7.846	1.561	8.827	1.756	78¾	
11½	0.997	5.880	1.196	6.859	1.396	7.839	1.595	8.819	1.794	78½	
11¾	1.018	5.874	1.222	6.853	1.425	7.832	1.629	8.811	1.833	78¼	
12°	1.040	5.869	1.247	6.847	1.455	7.825	1.663	8.803	1.871	78°	
12¼	1.061	5.863	1.273	6.841	1.485	7.818	1.697	8.795	1.910	77¾	
12½	1.082	5.858	1.299	6.834	1.515	7.810	1.732	8.787	1.948	77½	
12¾	1.103	5.852	1.324	6.827	1.545	7.803	1.766	8.778	1.986	77¼	
13°	1.125	5.846	1.350	6.821	1.575	7.795	1.800	8.769	2.025	77°	
Bearing.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Bearing.	
5	6	7	8	9							

LATITUDES AND DEPARTURES.

25

Bearing.	1		2		3		4		5		Bearing.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.		
13°	0.974	0.225	1.949	0.450	2.923	0.675	3.897	0.900	4.872	77°	
13¼	0.973	0.229	1.947	0.458	2.920	0.688	3.894	0.917	4.867	76¾	
13½	0.972	0.233	1.945	0.467	2.917	0.700	3.889	0.934	4.862	76½	
13¾	0.971	0.238	1.943	0.475	2.914	0.713	3.885	0.951	4.857	76¼	
14°	0.970	0.242	1.941	0.484	2.911	0.726	3.881	0.968	4.851	76°	
14¼	0.969	0.246	1.938	0.492	2.908	0.738	3.877	0.985	4.846	75¾	
14½	0.968	0.250	1.936	0.501	2.904	0.751	3.873	1.002	4.841	75½	
14¾	0.967	0.255	1.934	0.509	2.901	0.764	3.868	1.018	4.835	75¼	
15°	0.966	0.259	1.932	0.518	2.898	0.776	3.864	1.035	4.830	75°	
15¼	0.965	0.263	1.930	0.526	2.894	0.789	3.859	1.052	4.824	74¾	
15½	0.964	0.267	1.927	0.534	2.891	0.802	3.855	1.069	4.818	74½	
15¾	0.962	0.271	1.925	0.543	2.887	0.814	3.850	1.086	4.812	74¼	
16°	0.961	0.276	1.923	0.551	2.884	0.827	3.845	1.103	4.806	74°	
16¼	0.960	0.280	1.920	0.560	2.880	0.839	3.840	1.119	4.800	73¾	
16½	0.959	0.284	1.918	0.568	2.876	0.852	3.835	1.136	4.794	73½	
16¾	0.958	0.288	1.915	0.576	2.873	0.865	3.830	1.153	4.788	73¼	
17°	0.956	0.292	1.913	0.585	2.869	0.877	3.825	1.169	4.782	73°	
17¼	0.955	0.297	1.910	0.593	2.865	0.890	3.820	1.186	4.775	72¾	
17½	0.954	0.301	1.907	0.601	2.861	0.902	3.815	1.203	4.769	72½	
17¾	0.952	0.305	1.905	0.610	2.857	0.915	3.810	1.220	4.762	72¼	
18°	0.951	0.309	1.902	0.618	2.853	0.927	3.804	1.236	4.755	72°	
18¼	0.950	0.313	1.899	0.626	2.849	0.939	3.799	1.253	4.748	71¾	
18½	0.948	0.317	1.897	0.635	2.845	0.952	3.793	1.269	4.742	71½	
18¾	0.947	0.321	1.894	0.643	2.841	0.964	3.788	1.286	4.735	71¼	
19°	0.946	0.326	1.891	0.651	2.837	0.977	3.782	1.302	4.728	71°	
19¼	0.944	0.330	1.888	0.659	2.832	0.989	3.776	1.319	4.720	70¾	
19½	0.943	0.334	1.885	0.668	2.828	1.001	3.771	1.335	4.713	70½	
19¾	0.941	0.338	1.882	0.676	2.824	1.014	3.765	1.352	4.706	70¼	
20°	0.940	0.342	1.879	0.684	2.819	1.026	3.759	1.368	4.698	70°	
20¼	0.938	0.346	1.876	0.692	2.815	1.038	3.753	1.384	4.691	69¾	
20½	0.937	0.350	1.873	0.700	2.810	1.051	3.747	1.401	4.683	69½	
20¾	0.935	0.354	1.870	0.709	2.805	1.063	3.741	1.417	4.676	69¼	
21°	0.934	0.358	1.867	0.717	2.801	1.075	3.734	1.433	4.668	69°	
21¼	0.932	0.362	1.864	0.725	2.796	1.087	3.728	1.450	4.660	68¾	
21½	0.930	0.367	1.861	0.733	2.791	1.100	3.722	1.466	4.652	68½	
21¾	0.929	0.371	1.858	0.741	2.786	1.112	3.715	1.482	4.644	68¼	
22°	0.927	0.375	1.854	0.749	2.782	1.124	3.709	1.498	4.636	68°	
22¼	0.926	0.379	1.851	0.757	2.777	1.136	3.702	1.515	4.628	67¾	
22½	0.924	0.383	1.848	0.765	2.772	1.148	3.696	1.531	4.619	67½	
22¾	0.922	0.387	1.844	0.773	2.767	1.160	3.689	1.547	4.611	67¼	
23°	0.921	0.391	1.841	0.781	2.762	1.172	3.682	1.563	4.603	67°	
23¼	0.919	0.395	1.838	0.789	2.756	1.184	3.675	1.579	4.594	66¾	
23½	0.917	0.399	1.834	0.797	2.751	1.196	3.668	1.595	4.585	66½	
23¾	0.915	0.403	1.831	0.805	2.746	1.208	3.661	1.611	4.577	66¼	
24°	0.914	0.407	1.827	0.813	2.741	1.220	3.654	1.627	4.568	66°	
24¼	0.912	0.411	1.824	0.821	2.735	1.232	3.647	1.643	4.559	65¾	
24½	0.910	0.415	1.820	0.829	2.730	1.244	3.640	1.659	4.550	65½	
24¾	0.908	0.419	1.816	0.837	2.724	1.256	3.633	1.675	4.541	65¼	
25°	0.906	0.423	1.813	0.845	2.719	1.268	3.625	1.690	4.532	65°	
25¼	0.904	0.427	1.809	0.853	2.713	1.280	3.618	1.706	4.522	64¾	
25½	0.903	0.431	1.805	0.861	2.708	1.292	3.610	1.722	4.513	64½	
25¾	0.901	0.434	1.801	0.869	2.702	1.303	3.603	1.738	4.503	64¼	
26°	0.899	0.438	1.798	0.877	2.696	1.315	3.595	1.753	4.494	64°	
Bearing.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Bearing.	
	1	2	3	4	5						

LATITUDES AND DEPARTURES.

Bearing.	5		6		7		8		9		Bearing.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
13°	1.125	5.846	1.350	6.821	1.575	7.795	1.800	8.769	2.025	77°	
13¼	1.146	5.840	1.375	6.814	1.604	7.787	1.834	8.760	2.063	76¾	
13½	1.167	5.834	1.401	6.807	1.634	7.779	1.868	8.751	2.101	76½	
13¾	1.188	5.828	1.426	6.799	1.664	7.771	1.902	8.742	2.139	76¼	
14°	1.210	5.822	1.452	6.792	1.693	7.762	1.935	8.733	2.177	76°	
14¼	1.231	5.815	1.477	6.785	1.723	7.754	1.969	8.723	2.215	75¾	
14½	1.252	5.809	1.502	6.777	1.753	7.745	2.003	8.713	2.253	75½	
14¾	1.273	5.802	1.528	6.769	1.782	7.736	2.037	8.703	2.291	75¼	
15°	1.294	5.796	1.553	6.761	1.812	7.727	2.071	8.693	2.329	75°	
15¼	1.315	5.789	1.578	6.754	1.841	7.718	2.104	8.683	2.367	74¾	
15½	1.336	5.782	1.603	6.745	1.871	7.709	2.138	8.673	2.405	74½	
15¾	1.357	5.775	1.629	6.737	1.900	7.700	2.172	8.662	2.443	74¼	
16°	1.378	5.768	1.654	6.729	1.929	7.690	2.205	8.651	2.481	74°	
16¼	1.399	5.760	1.679	6.720	1.959	7.680	2.239	8.640	2.518	73¾	
16½	1.420	5.753	1.704	6.712	1.988	7.671	2.272	8.629	2.556	73½	
16¾	1.441	5.745	1.729	6.703	2.017	7.661	2.306	8.618	2.594	73¼	
17°	1.462	5.738	1.754	6.694	2.047	7.650	2.339	8.607	2.631	73°	
17¼	1.483	5.730	1.779	6.685	2.076	7.640	2.372	8.595	2.669	72¾	
17½	1.504	5.722	1.804	6.676	2.105	7.630	2.406	8.583	2.706	72½	
17¾	1.524	5.714	1.829	6.667	2.134	7.619	2.439	8.572	2.744	72¼	
18°	1.545	5.706	1.854	6.657	2.163	7.608	2.472	8.560	2.781	72°	
18¼	1.566	5.698	1.879	6.648	2.192	7.598	2.505	8.547	2.818	71¾	
18½	1.587	5.690	1.904	6.638	2.221	7.587	2.538	8.535	2.856	71½	
18¾	1.607	5.682	1.929	6.629	2.250	7.575	2.572	8.522	2.893	71¼	
19°	1.628	5.673	1.953	6.619	2.279	7.564	2.605	8.510	2.930	71°	
19¼	1.648	5.665	1.978	6.609	2.308	7.553	2.638	8.497	2.967	70¾	
19½	1.669	5.656	2.003	6.598	2.337	7.541	2.670	8.484	3.004	70½	
19¾	1.690	5.647	2.028	6.588	2.365	7.529	2.703	8.471	3.041	70¼	
20°	1.710	5.638	2.052	6.578	2.394	7.518	2.736	8.457	3.078	70°	
20¼	1.731	5.629	2.077	6.567	2.423	7.506	2.769	8.444	3.115	69¾	
20½	1.751	5.620	2.101	6.557	2.451	7.493	2.802	8.430	3.152	69½	
20¾	1.771	5.611	2.126	6.546	2.480	7.481	2.834	8.416	3.189	69¼	
21°	1.792	5.601	2.150	6.535	2.509	7.469	2.867	8.402	3.225	69°	
21¼	1.812	5.592	2.175	6.524	2.537	7.456	2.900	8.388	3.262	68¾	
21½	1.833	5.582	2.199	6.513	2.566	7.443	2.932	8.374	3.299	68½	
21¾	1.853	5.573	2.223	6.502	2.594	7.430	2.964	8.359	3.335	68¼	
22°	1.873	5.563	2.248	6.490	2.622	7.417	2.997	8.345	3.371	68°	
22¼	1.893	5.553	2.272	6.479	2.651	7.404	3.029	8.330	3.408	67¾	
22½	1.913	5.543	2.296	6.467	2.679	7.391	3.061	8.315	3.444	67½	
22¾	1.934	5.533	2.320	6.455	2.707	7.378	3.094	8.300	3.480	67¼	
23°	1.954	5.523	2.344	6.444	2.735	7.364	3.126	8.285	3.517	67°	
23¼	1.974	5.513	2.368	6.432	2.763	7.350	3.158	8.269	3.553	66¾	
23½	1.994	5.502	2.392	6.419	2.791	7.336	3.190	8.254	3.589	66½	
23¾	2.014	5.492	2.416	6.407	2.819	7.322	3.222	8.238	3.625	66¼	
24°	2.034	5.481	2.440	6.395	2.847	7.308	3.254	8.222	3.661	66°	
24¼	2.054	5.471	2.464	6.382	2.875	7.294	3.286	8.206	3.696	65¾	
24½	2.073	5.460	2.488	6.370	2.903	7.280	3.318	8.190	3.732	65½	
24¾	2.093	5.449	2.512	6.357	2.931	7.265	3.349	8.173	3.768	65¼	
25°	2.113	5.438	2.536	6.344	2.958	7.250	3.381	8.157	3.804	65°	
25¼	2.133	5.427	2.559	6.331	2.986	7.236	3.413	8.140	3.839	64¾	
25½	2.153	5.416	2.583	6.318	3.014	7.221	3.444	8.123	3.875	64½	
25¾	2.172	5.404	2.607	6.305	3.041	7.206	3.476	8.106	3.910	64¼	
26°	2.192	5.393	2.630	6.292	3.069	7.190	3.507	8.089	3.945	64°	
Bearing.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Bearing.	
	5	6		7		8		9			

LATITUDES AND DEPARTURES.

27

Bearing.	1		2		3		4		5	Bearing.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
26°	0.899	0.438	1.798	0.877	2.696	1.315	3.595	1.753	4.494	64°
26 1/4	0.897	0.442	1.794	0.885	2.691	1.327	3.587	1.769	4.484	63 3/4
26 1/2	0.895	0.446	1.790	0.892	2.685	1.339	3.580	1.785	4.475	63 1/2
26 3/4	0.893	0.450	1.786	0.900	2.679	1.350	3.572	1.800	4.465	63 1/4
27°	0.891	0.454	1.782	0.908	2.673	1.362	3.564	1.816	4.455	63°
27 1/4	0.889	0.458	1.778	0.916	2.667	1.374	3.556	1.831	4.445	62 3/4
27 1/2	0.887	0.462	1.774	0.923	2.661	1.385	3.548	1.847	4.435	62 1/2
27 3/4	0.885	0.466	1.770	0.931	2.655	1.397	3.540	1.862	4.425	62 1/4
28°	0.883	0.469	1.766	0.939	2.649	1.408	3.532	1.878	4.415	62°
28 1/4	0.881	0.473	1.762	0.947	2.643	1.420	3.524	1.893	4.404	61 3/4
28 1/2	0.879	0.477	1.758	0.954	2.636	1.431	3.515	1.909	4.394	61 1/2
28 3/4	0.877	0.481	1.753	0.962	2.630	1.443	3.507	1.924	4.384	61 1/4
29°	0.875	0.485	1.749	0.970	2.624	1.454	3.498	1.939	4.373	61°
29 1/4	0.872	0.489	1.745	0.977	2.617	1.466	3.490	1.954	4.362	60 3/4
29 1/2	0.870	0.492	1.741	0.985	2.611	1.477	3.481	1.970	4.352	60 1/2
29 3/4	0.868	0.496	1.736	0.992	2.605	1.489	3.473	1.985	4.341	60 1/4
30°	0.866	0.500	1.732	1.000	2.598	1.500	3.464	2.000	4.330	60°
30 1/4	0.864	0.504	1.728	1.008	2.592	1.511	3.455	2.015	4.319	59 3/4
30 1/2	0.862	0.508	1.723	1.015	2.585	1.523	3.447	2.030	4.308	59 1/2
30 3/4	0.859	0.511	1.719	1.023	2.578	1.534	3.438	2.045	4.297	59 1/4
31°	0.857	0.515	1.714	1.030	2.572	1.545	3.429	2.060	4.286	59°
31 1/4	0.855	0.519	1.710	1.038	2.565	1.556	3.420	2.075	4.275	58 3/4
31 1/2	0.853	0.522	1.705	1.045	2.558	1.567	3.411	2.090	4.263	58 1/2
31 3/4	0.850	0.526	1.701	1.052	2.551	1.579	3.401	2.105	4.252	58 1/4
32°	0.848	0.530	1.696	1.060	2.544	1.590	3.392	2.120	4.240	58°
32 1/4	0.846	0.534	1.691	1.067	2.537	1.601	3.383	2.134	4.229	57 3/4
32 1/2	0.843	0.537	1.687	1.075	2.530	1.612	3.374	2.149	4.217	57 1/2
32 3/4	0.841	0.541	1.682	1.082	2.523	1.623	3.364	2.164	4.205	57 1/4
33°	0.839	0.545	1.677	1.089	2.516	1.634	3.355	2.179	4.193	57°
33 1/4	0.836	0.548	1.673	1.097	2.509	1.645	3.345	2.193	4.181	56 3/4
33 1/2	0.834	0.552	1.668	1.104	2.502	1.656	3.336	2.208	4.169	56 1/2
33 3/4	0.831	0.556	1.663	1.111	2.494	1.667	3.326	2.222	4.157	56 1/4
34°	0.829	0.559	1.658	1.118	2.487	1.678	3.316	2.237	4.145	56°
34 1/4	0.827	0.563	1.653	1.126	2.480	1.688	3.306	2.251	4.133	55 3/4
34 1/2	0.824	0.566	1.648	1.133	2.472	1.699	3.297	2.266	4.121	55 1/2
34 3/4	0.822	0.570	1.643	1.140	2.465	1.710	3.287	2.280	4.108	55 1/4
35°	0.819	0.574	1.638	1.147	2.457	1.721	3.277	2.294	4.096	55°
35 1/4	0.817	0.577	1.633	1.154	2.450	1.731	3.267	2.309	4.083	54 3/4
35 1/2	0.814	0.581	1.628	1.161	2.442	1.742	3.257	2.323	4.071	54 1/2
35 3/4	0.812	0.584	1.623	1.168	2.435	1.753	3.246	2.337	4.058	54 1/4
36°	0.809	0.588	1.618	1.176	2.427	1.763	3.236	2.351	4.045	54°
36 1/4	0.806	0.591	1.613	1.183	2.419	1.774	3.226	2.365	4.032	53 3/4
36 1/2	0.804	0.595	1.608	1.190	2.412	1.784	3.215	2.379	4.019	53 1/2
36 3/4	0.801	0.598	1.603	1.197	2.404	1.795	3.205	2.393	4.006	53 1/4
37°	0.799	0.602	1.597	1.204	2.396	1.805	3.195	2.407	3.993	53°
37 1/4	0.796	0.605	1.592	1.211	2.388	1.816	3.184	2.421	3.980	52 3/4
37 1/2	0.793	0.609	1.587	1.218	2.380	1.826	3.173	2.435	3.967	52 1/2
37 3/4	0.791	0.612	1.581	1.224	2.372	1.837	3.163	2.449	3.953	52 1/4
38°	0.788	0.616	1.576	1.231	2.364	1.847	3.152	2.463	3.940	52°
38 1/4	0.785	0.619	1.571	1.238	2.356	1.857	3.141	2.476	3.927	51 3/4
38 1/2	0.783	0.623	1.565	1.245	2.348	1.868	3.130	2.490	3.913	51 1/2
38 3/4	0.780	0.626	1.560	1.252	2.340	1.878	3.120	2.504	3.899	51 1/4
39°	0.777	0.629	1.554	1.259	2.331	1.888	3.109	2.517	3.886	51°
Bearing.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Bearing.
	1		2		3		4		5	

LATITUDES AND DEPARTURES.

Bearing.	5		6		7		8		9		Bearing.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.		
26°	2.192	5.393	2.630	6.292	3.069	7.190	3.507	8.089	3.945	64°	
26 1/4	2.211	5.381	2.654	6.278	3.096	7.175	3.538	8.072	3.981	63 3/4	
26 1/2	2.231	5.370	2.677	6.265	3.123	7.160	3.570	8.054	4.016	63 1/2	
26 3/4	2.250	5.358	2.701	6.251	3.151	7.144	3.601	8.037	4.051	63 1/4	
27°	2.270	5.346	2.724	6.237	3.178	7.128	3.632	8.019	4.086	63°	
27 1/4	2.289	5.334	2.747	6.223	3.205	7.112	3.663	8.001	4.121	62 3/4	
27 1/2	2.309	5.322	2.770	6.209	3.232	7.096	3.694	7.983	4.156	62 1/2	
27 3/4	2.328	5.310	2.794	6.195	3.259	7.080	3.725	7.965	4.190	62 1/4	
28°	2.347	5.298	2.817	6.181	3.286	7.064	3.756	7.947	4.225	62°	
28 1/4	2.367	5.285	2.840	6.166	3.313	7.047	3.787	7.928	4.260	61 3/4	
28 1/2	2.386	5.273	2.863	6.152	3.340	7.031	3.817	7.909	4.294	61 1/2	
28 3/4	2.405	5.260	2.886	6.137	3.367	7.014	3.848	7.891	4.329	61 1/4	
29°	2.424	5.248	2.909	6.122	3.394	6.997	3.878	7.872	4.363	61°	
29 1/4	2.443	5.235	2.932	6.107	3.420	6.980	3.909	7.852	4.398	60 3/4	
29 1/2	2.462	5.222	2.955	6.093	3.447	6.963	3.939	7.833	4.432	60 1/2	
29 3/4	2.481	5.209	2.977	6.077	3.474	6.946	3.970	7.814	4.466	60 1/4	
30°	2.500	5.196	3.000	6.062	3.500	6.928	4.000	7.794	4.500	60°	
30 1/4	2.519	5.183	3.023	6.047	3.526	6.911	4.030	7.775	4.534	59 3/4	
30 1/2	2.538	5.170	3.045	6.031	3.553	6.893	4.060	7.755	4.568	59 1/2	
30 3/4	2.556	5.156	3.068	6.016	3.579	6.875	4.090	7.735	4.602	59 1/4	
31°	2.575	5.143	3.090	6.000	3.605	6.857	4.120	7.715	4.635	59°	
31 1/4	2.594	5.129	3.113	5.984	3.631	6.839	4.150	7.694	4.669	58 3/4	
31 1/2	2.612	5.116	3.135	5.968	3.657	6.821	4.180	7.674	4.702	58 1/2	
31 3/4	2.631	5.102	3.157	5.952	3.683	6.803	4.210	7.653	4.736	58 1/4	
32°	2.650	5.088	3.180	5.936	3.709	6.784	4.239	7.632	4.769	58°	
32 1/4	2.668	5.074	3.202	5.920	3.735	6.766	4.269	7.612	4.802	57 3/4	
32 1/2	2.686	5.060	3.224	5.904	3.761	6.747	4.298	7.591	4.836	57 1/2	
32 3/4	2.705	5.046	3.246	5.887	3.787	6.728	4.328	7.569	4.869	57 1/4	
33°	2.723	5.032	3.268	5.871	3.812	6.709	4.357	7.548	4.902	57°	
33 1/4	2.741	5.018	3.290	5.854	3.838	6.690	4.386	7.527	4.935	56 3/4	
33 1/2	2.760	5.003	3.312	5.837	3.864	6.671	4.416	7.505	4.967	56 1/2	
33 3/4	2.778	4.989	3.333	5.820	3.889	6.652	4.445	7.483	5.000	56 1/4	
34°	2.796	4.974	3.355	5.803	3.914	6.632	4.474	7.461	5.033	56°	
34 1/4	2.814	4.960	3.377	5.786	3.940	6.613	4.502	7.439	5.065	55 3/4	
34 1/2	2.832	4.945	3.398	5.769	3.965	6.593	4.531	7.417	5.098	55 1/2	
34 3/4	2.850	4.930	3.420	5.752	3.990	6.573	4.560	7.395	5.130	55 1/4	
35°	2.868	4.915	3.441	5.734	4.015	6.553	4.589	7.372	5.162	55°	
35 1/4	2.886	4.900	3.463	5.716	4.040	6.533	4.617	7.350	5.194	54 3/4	
35 1/2	2.904	4.885	3.484	5.699	4.065	6.513	4.646	7.327	5.226	54 1/2	
35 3/4	2.921	4.869	3.505	5.681	4.090	6.493	4.674	7.304	5.258	54 1/4	
36°	2.939	4.854	3.527	5.663	4.115	6.472	4.702	7.281	5.290	54°	
36 1/4	2.957	4.839	3.548	5.645	4.139	6.452	4.730	7.258	5.322	53 3/4	
36 1/2	2.974	4.823	3.569	5.627	4.164	6.431	4.759	7.235	5.353	53 1/2	
36 3/4	2.992	4.808	3.590	5.609	4.188	6.410	4.787	7.211	5.385	53 1/4	
37°	3.009	4.792	3.611	5.590	4.213	6.389	4.815	7.188	5.416	53°	
37 1/4	3.026	4.776	3.632	5.572	4.237	6.368	4.842	7.164	5.448	52 3/4	
37 1/2	3.044	4.760	3.653	5.554	4.261	6.347	4.870	7.140	5.479	52 1/2	
37 3/4	3.061	4.744	3.673	5.535	4.286	6.326	4.898	7.116	5.510	52 1/4	
38°	3.078	4.728	3.694	5.516	4.310	6.304	4.925	7.092	5.541	52°	
38 1/4	3.095	4.712	3.715	5.497	4.334	6.283	4.953	7.068	5.572	51 3/4	
38 1/2	3.113	4.696	3.735	5.478	4.358	6.261	4.980	7.043	5.603	51 1/2	
38 3/4	3.130	4.679	3.756	5.459	4.381	6.239	5.007	7.019	5.633	51 1/4	
39°	3.147	4.663	3.776	5.440	4.405	6.217	5.035	6.994	5.664	51°	
Bearing.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Bearing.	
	5	6	7	8	9						

LATITUDES AND DEPARTURES.

29

Bearing.	1		2		3		4		5	Bearing.
	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	
39°	0.777	0.629	1.554	1.259	2.331	1.888	3.109	2.517	3.886	51°
39 1/4	0.774	0.633	1.549	1.265	2.323	1.898	3.098	2.531	3.872	50 3/4
39 1/2	0.772	0.636	1.543	1.272	2.315	1.908	3.086	2.544	3.858	50 1/2
39 3/4	0.769	0.639	1.538	1.279	2.307	1.918	3.075	2.558	3.844	50 1/4
40°	0.766	0.643	1.532	1.286	2.298	1.928	3.064	2.571	3.830	50°
40 1/4	0.763	0.646	1.526	1.292	2.290	1.938	3.053	2.584	3.816	49 3/4
40 1/2	0.760	0.649	1.521	1.299	2.281	1.948	3.042	2.598	3.802	49 1/2
40 3/4	0.758	0.653	1.515	1.306	2.273	1.958	3.030	2.611	3.788	49 1/4
41°	0.755	0.656	1.509	1.312	2.264	1.968	3.019	2.624	3.774	49°
41 1/4	0.752	0.659	1.504	1.319	2.256	1.978	3.007	2.637	3.759	48 3/4
41 1/2	0.749	0.663	1.498	1.325	2.247	1.988	2.996	2.650	3.745	48 1/2
41 3/4	0.746	0.666	1.492	1.332	2.238	1.998	2.984	2.664	3.730	48 1/4
42°	0.743	0.669	1.486	1.338	2.229	2.007	2.973	2.677	3.716	48°
42 1/4	0.740	0.672	1.480	1.345	2.221	2.017	2.961	2.689	3.701	47 3/4
42 1/2	0.737	0.676	1.475	1.351	2.212	2.027	2.949	2.702	3.686	47 1/2
42 3/4	0.734	0.679	1.469	1.358	2.203	2.036	2.937	2.715	3.672	47 1/4
43°	0.731	0.682	1.463	1.364	2.194	2.046	2.925	2.728	3.657	47°
43 1/4	0.728	0.685	1.457	1.370	2.185	2.056	2.913	2.741	3.642	46 3/4
43 1/2	0.725	0.688	1.451	1.377	2.176	2.065	2.901	2.753	3.627	46 1/2
43 3/4	0.722	0.692	1.445	1.383	2.167	2.075	2.889	2.766	3.612	46 1/4
44°	0.719	0.695	1.439	1.389	2.158	2.084	2.877	2.779	3.597	46°
44 1/4	0.716	0.698	1.433	1.396	2.149	2.093	2.865	2.791	3.582	45 3/4
44 1/2	0.713	0.701	1.427	1.402	2.140	2.103	2.853	2.804	3.566	45 1/2
44 3/4	0.710	0.704	1.420	1.408	2.131	2.112	2.841	2.816	3.551	45 1/4
45°	0.707	0.707	1.414	1.414	2.121	2.121	2.828	2.828	3.536	45°
B'ring	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	B'ring

Bearing.	5	6		7		8		9		Bearing.
	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	
39°	3.147	4.663	3.776	5.440	4.405	6.217	5.035	6.994	5.664	51°
39 1/4	3.164	4.646	3.796	5.421	4.429	6.195	5.062	6.970	5.694	50 3/4
39 1/2	3.180	4.630	3.816	5.401	4.453	6.173	5.089	6.945	5.725	50 1/2
39 3/4	3.197	4.613	3.837	5.382	4.476	6.151	5.116	6.920	5.755	50 1/4
40°	3.214	4.596	3.857	5.362	4.500	6.128	5.142	6.894	5.785	50°
40 1/4	3.231	4.579	3.877	5.343	4.523	6.106	5.169	6.869	5.815	49 3/4
40 1/2	3.247	4.562	3.897	5.323	4.546	6.083	5.196	6.844	5.845	49 1/2
40 3/4	3.264	4.545	3.917	5.303	4.569	6.061	5.222	6.818	5.875	49 1/4
41°	3.280	4.528	3.936	5.283	4.592	6.038	5.248	6.792	5.905	49°
41 1/4	3.297	4.511	3.956	5.263	4.615	6.015	5.275	6.767	5.934	48 3/4
41 1/2	3.313	4.494	3.976	5.243	4.638	5.992	5.301	6.741	5.964	48 1/2
41 3/4	3.329	4.476	3.995	5.222	4.661	5.968	5.327	6.715	5.993	48 1/4
42°	3.346	4.459	4.015	5.202	4.684	5.945	5.353	6.688	6.022	48°
42 1/4	3.362	4.441	4.034	5.182	4.707	5.922	5.379	6.662	6.051	47 3/4
42 1/2	3.378	4.424	4.054	5.161	4.729	5.898	5.405	6.635	6.080	47 1/2
42 3/4	3.394	4.406	4.073	5.140	4.752	5.875	5.430	6.609	6.109	47 1/4
43°	3.410	4.388	4.092	5.119	4.774	5.851	5.456	6.582	6.138	47°
43 1/4	3.426	4.370	4.111	5.099	4.796	5.827	5.481	6.555	6.167	46 3/4
43 1/2	3.442	4.352	4.130	5.078	4.818	5.803	5.507	6.528	6.195	46 1/2
43 3/4	3.458	4.334	4.149	5.057	4.841	5.779	5.532	6.501	6.224	46 1/4
44°	3.473	4.316	4.168	5.035	4.863	5.755	5.557	6.474	6.252	46°
44 1/4	3.489	4.298	4.187	5.014	4.885	5.730	5.582	6.447	6.280	45 3/4
44 1/2	3.505	4.280	4.206	4.993	4.906	5.706	5.607	6.419	6.308	45 1/2
44 3/4	3.520	4.261	4.224	4.971	4.928	5.681	5.632	6.392	6.336	45 1/4
45°	3.536	4.243	4.243	4.950	4.950	5.657	5.657	6.364	6.364	45°
B'ring	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	Dep.	Lat.	B'ring

TABLE OF RADII AND DEFLECTIONS OF CURVES.

De- gree.	Radii.	Chord Deflec- tion.	Tan- gent Deflec- tion.	De- gree.	Radii.	Chord Deflec- tion.	Tan- gent Deflec- tion.	De- gree.	Radii.	Chord Deflec- tion.	Tan- gent Deflec- tion.					
0	5	68754.94	.145	.073	5	15	1091.73	9.160	4.580	10	50	529.67	18.880	9.440		
		34377.48	.291	.145			20	1074.68	9.305	4.653						
		22918.33	.436	.218			25	1058.16	9.450	4.725	11	0	521.67	19.169	9.585	
		17188.76	.582	.291			30	1042.14	9.596	4.798			573.91	19.459	9.729	
		13751.02	.727	.364			35	1026.60	9.741	4.870			506.38	19.748	9.874	
		11459.19	.873	.436			40	1011.51	9.886	4.943	30		499.06	20.038	10.019	
		9822.18	1.018	.509			45	996.87	10.031	5.016			491.96	20.327	10.164	
		8504.41	1.164	.582			50	982.64	10.177	5.088	50		485.05	20.616	10.308	
		7639.49	1.309	.654			55	968.81	10.322	5.161						
		6875.55	1.454	.727							12	0	478.34	20.906	10.453	
		6250.51	1.600	.800			6	0	955.37	10.467	5.234	10		471.81	21.195	10.597
									942.29	10.612	5.306			465.46	21.484	10.742
							10	0	929.57	10.758	5.379	30		459.28	21.773	10.887
							15	0	917.10	10.903	5.451			453.26	22.063	11.031
							20	0	905.13	11.048	5.524	50		447.40	22.352	11.176
							25	0	893.39	11.193	5.597					
							30	0	881.95	11.339	5.669	13	0	441.68	22.641	11.320
							35	0	870.79	11.484	5.742			436.12	22.930	11.465
							40	0	859.92	11.629	5.814	20		430.69	23.219	11.609
							45	0	849.37	11.774	5.887	30		425.40	23.507	11.754
							50	0	839.97	11.919	5.960	40		420.23	23.796	11.898
							55	0	828.08	12.065	6.032	50		415.19	24.085	12.043
							7	0	819.02	12.210	6.105	14	0	410.28	24.374	12.187
									800.40	12.355	6.177	10		405.47	24.663	12.331
									800.00	12.500	6.250	20		400.78	24.951	12.476
							15	0	790.81	12.645	6.323	30		396.20	25.240	12.620
							20	0	781.84	12.790	6.395	40		391.72	25.528	12.764
							25	0	773.07	12.936	6.468	50		387.34	25.817	12.908
							30	0	764.49	13.081	6.540					
							35	0	756.10	13.226	6.613	15	0	383.06	26.105	13.053
							40	0	747.89	13.371	6.685	20		378.88	26.394	13.197
							45	0	739.86	13.516	6.758	30		374.79	26.682	13.341
							50	0	732.01	13.661	6.831	30		370.78	26.970	13.485
							55	0	724.31	13.806	6.903	40		366.86	27.258	13.629
												50		363.02	27.547	13.773
							8	0	716.78	13.951	6.976					
									709.40	14.096	7.048	16	0	359.26	27.835	13.917
							10	0	702.18	14.241	7.121	20		355.59	28.123	14.061
							15	0	695.00	14.387	7.193	30		351.98	28.411	14.205
							20	0	688.16	14.532	7.266	30		348.45	28.699	14.349
							25	0	681.35	14.677	7.338	40		344.99	28.986	14.493
							30	0	674.69	14.822	7.411	50		341.60	29.274	14.637
							35	0	668.15	14.967	7.483					
							40	0	661.74	15.112	7.556	17	0	338.27	29.562	14.781
							45	0	655.45	15.257	7.628	20		335.01	29.850	14.925
							50	0	649.27	15.402	7.701	30		331.82	30.137	15.069
							55	0	643.22	15.547	7.773	30		328.68	30.425	15.212
												40		325.60	30.712	15.356
												50		322.59	31.000	15.500
							9	0	637.27	15.692	7.846					
									631.44	15.837	7.918					
							5	0	625.71	15.982	7.991	18	0	319.62	31.287	15.643
							10	0	619.00	16.127	8.063	20		316.71	31.574	15.787
							20	0	614.56	16.272	8.136	30		313.86	31.861	15.931
							25	0	609.14	16.417	8.208	30		311.06	32.149	16.074
							30	0	603.80	16.562	8.281	40		308.30	32.436	16.218
							35	0	598.57	16.707	8.353	50		305.60	32.723	16.361
							40	0	593.42	16.852	8.426					
							45	0	588.36	16.996	8.498	19	0	302.94	33.010	16.505
							50	0	583.38	17.141	8.571	20		300.33	33.296	16.648
							55	0	578.49	17.286	8.643	20		297.77	33.583	16.792
												30		295.25	33.870	16.935
												40		292.77	34.157	17.078
												50		290.33	34.443	17.222
							10	0	573.69	17.431	8.716					
							20	0	564.31	17.721	8.860					
							30	0	555.23	18.011	9.005					
							40	0	546.44	18.300	9.150	20	0	287.94	34.730	17.365
							40	0	537.92	18.590	9.295					

SPECIFIC GRAVITIES AND WEIGHTS PER CUBIC FOOT.

METALS.

Substance.	Specific Gravity.	Weight per Cubic Foot in Pounds.
Osmium.....	23.00	1,437.5
Platinum	21.50	1,343.8
Gold.....	19.50	1,218.8
Mercury	13.60	850.0
Lead (cast).....	11.35	709.4
Silver.....	10.50	656.3
Copper (cast).....	8.79	549.4
Brass	8.38	523.8
Wrought Iron	7.68	480.0
Cast Iron	7.21	450.0
Steel	7.84	490.0
Tin (cast).....	7.29	455.6
Zinc (cast)	6.86	428.8
Antimony.....	6.71	419.4
Aluminum	2.50	156.3

WOODS.

Substance.	Specific Gravity.	Weight per Cubic Foot in Pounds.
Ash	.845	52.80
Beech	.852	53.25
Cedar.....	.561	35.06
Cork	.240	15.00
Ebony (American).....	1.331	83.19
Lignum-vitæ	1.333	83.30
Maple	.750	46.88
Oak (old)	1.170	73.10
Spruce.....	.500	31.25
Pine (yellow).....	.660	41.20
Pine (white).....	.554	34.60
Walnut	.671	41.90

LIQUIDS.

Substance.	Specific Gravity.	Weight per Cubic Foot in Pounds.
Acetic Acid	1.062	66.4
Nitric Acid	1.217	76.1
Sulphuric Acid	1.841	115.1
Muriatic Acid	1.200	75.0
Alcohol	.800	50.0
Turpentine.....	.870	54.4
Sea Water (ordinary)	1.026	64.1
Milk.....	1.032	64.5

GASES.

At 32° F., and under a Pressure of One Atmosphere.

Substance.	Specific Gravity.	Weight per Cubic Foot in Pounds.
Atmospheric Air.....	1.0000	.08073
Carbonic Acid.....	1.5290	.12344
Carbonic Oxide.....	.9674	.07810
Chlorine	2.4400	.19700
Oxygen	1.1056	.08925
Nitrogen.....	.9736	.07860
Smoke (bituminous coal).....	.1020	.00815
Smoke (wood).....	.0900	.00727
*Steam at 212° F.....	.4700	.03790
Hydrogen.....	.0692	.00559

* The specific gravity of steam at any temperature and pressure compared with air at the same temperature and pressure is 0.622.

MISCELLANEOUS.

Substance.	Specific Gravity.	Weight per Cubic Foot in Pounds.
Emery	4.00	250
Glass (average).....	2.80	175
Chalk.	2.78	174
Granite.....	2.65	166
Marble	2.70	169
Stone (common).....	2.52	158
Salt (common).....	2.13	133
Soil (common)	1.98	124
Clay.....	1.93	121
Brick.....	1.90	118
Plaster Paris (average).....	2.00	125
Sand	1.80	113

SPECIFIC HEAT OF VARIOUS SUBSTANCES.

Substance.	Sp. Heat.	Substance.	Sp. Heat.
Water.....	1.0000	Ice.....	.5040
Sulphur	.2026	Steam (superheated).....	.4805
Iron.....	.1138	Air	.2375
Copper	.0951	Oxygen	.2175
Silver.....	.0570	Hydrogen.....	3.4090
Tin.....	.0562	Nitrogen.....	.2438
Mercury	.0333	Carbon Monoxide....	.2479
Lead	.0314	Carbon Dioxide.....	.2170

ANALYSES OF COAL.

	Car- bon.	Hydro-Carbons.			Sulph.	Ash.
		Hydro.	Oxyg.	Nitro.		
Pocahontas, Va.....	72.71	18.81			0.79	5.19
Connellsville, Pa.....	59.79	31.80			0.53	7.16
Anthracite, S. Wales	92.56	3.33	2.53	.....	.....	1.58
Anthracite, Pa.....	92.59	2.63	1.61	0.92	.....	2.25
Anthracite, Pa.....	90.45	2.43	2.45	.....	.....	4.67
Caking Coal, Kentucky.....	74.45	4.93	13.08	1.03	0.91	5.00
Caking Coal, Nelsonville, O...	73.80	5.79	16.58	1.52	0.41	1.90
Caking Coal, South Wales	82.56	5.36	8.22	1.65	0.75	1.46
Caking Coal, Northumberland	78.69	6.00	10.07	2.37	1.51	1.36
Non-Caking, Kentucky	77.89	5.42	12.57	1.82	3.00	2.00
Non-Caking, Block Coal, Ind..	82.70	4.77	9.39	1.62	0.45	1.07
Non-Caking, Briar Hill, O....	78.94	5.92	11.50	1.58	0.56	1.45
Non-Caking, S. Staffordshire..	76.40	4.62	17.43	.....	0.55	1.55
Non-Caking, Scotland	76.08	5.31	13.33	2.09	1.23	1.96
Cannel Coal, Breckenridge, Ky.	68.13	6.49	5.83	2.27	2.48	12.30
Cannel Coal, Wigan, Eng.....	80.07	5.53	8.10	2.12	1.50	2.70
Cannel Coal, "Torbanite"....	64.02	8.90	5.66	0.55	0.50	20.32
Albertite, Nova Scotia.....	86.04	8.96	1.97	2.93	trace	0.10
Brown Coal, Bovey	66.31	5.63	22.86	0.57	2.36	2.27
Brown Coal, Wittenburg.....	64.07	5.03	27.55	.....	.....	3.85
Brown Coal, Carbon, Wy.....	75.20	4.74	10.37	1.37	1.11	7.20
Peat, light brown (imperfect)..	50.86	5.80	42.57	0.77	.....	.....
Peat, dark brown.....	59.47	6.52	31.51	2.51	.....	.....
Peat, black	59.70	5.70	33.04	1.56	.....	.....
Peat, black	59.71	5.27	32.07	2.59	.....	.....
Non-Coking, Bon-Air, Tenn...	58.00	Vola. matter 37%			0.75	4.00
Coking, Tracy City, Tenn....	61.00	Vola. matter 29.30%			trace	7.00

COKING AND NON-COKING COALS.

	Moist.	Volatile Matter.	Fixed Carbon.	Ash.	Sulphur.	Phos.	Remarks.	Formation Mined in.
Connellsville, Pa.....	1.25	31.80	59.79	7.16	0.53	0.024	Best Coking Coal	Carboniferous
Pocahontas, Va.	1.011	18.812	72.708	5.191	0.787		Good Coking Coal	Carboniferous
Broad Top, Pa.....	1.28	18.40	71.12	5.50	1.70	traces	Good Coking Coal	Carboniferous
Bennington, Pa.	1.20	23.68	68.77	5.73	0.62	0.017	Good Coking Coal	Carboniferous
Johnstown, Pa.	0.72	16.49	73.84	7.97	1.97		Dry Coking Coal	Carboniferous
Greensburg, Pa.	1.02	33.50	61.34	3.28	0.86		Good Coking Coal	Carboniferous
Armstrong Co., Pa.....	0.96	38.20	52.03	5.14	3.66		Pitchy Coking Coal	Carboniferous
Mt. Carbon, Ill.....	2.08	38.20	53.47	8.02	0.63	0.027	Pitchy Coking Coal	Carboniferous
El Moro, Col.....	0.95	29.82	56.41	12.82	0.41		Good Coking Coal	Cretaceous
Crested Butte, Col.....	0.72	23.44	71.91	3.93	0.36		Good Coking Coal	Cretaceous
Sand Coulee, Mont.....	2.26	33.60	54.47	7.82	1.86	0.009	Non-Coking Coal	Cretaceous
Beet Mountain, Mont.....	2.98	28.71	53.31	13.34	1.65	0.012	Non-Coking Coal	Cretaceous
Coahuila, Mex.....	1.60	15.00	67.64	12.01	0.86		Coking Coal	?

CHEMICAL ELEMENTS.

Name.	Symbol.	Atomic Weight.	Name.	Symbol.	Atomic Weight.
* Aluminium,	<i>Al.</i>	27.4	Mercury,	<i>Hg.</i>	200.0
* Antimony,	<i>Sb.</i>	122.0	* Molybdenum,	<i>Mo.</i>	96.0
* Arsenic,	<i>As.</i>	75.0	Nickel,	<i>Ni.</i>	58.0
Barium,	<i>Ba.</i>	137.0	Niobium (Col- umbium, Cb.),	<i>Nb.</i>	94.0
Beryllium (Glu- cinum, Gl.),	<i>Be.</i>	9.2	Nitrogen,	<i>N.</i>	14.0
Bismuth,	<i>Bi.</i>	210.0	Osmium,	<i>Os.</i>	200.0
Boron,	<i>B.</i>	11.0	Oxygen,	<i>O.</i>	16.0
<i>Bromine,</i>	<i>Br.</i>	80.0	Palladium,	<i>Pd.</i>	106.0
Cadmium,	<i>Cd.</i>	112.0	* Phosphorus,	<i>P.</i>	31.0
Cæsium,	<i>Cs.</i>	133.0	Platinum,	<i>Pt.</i>	197.4
Calcium,	<i>Ca.</i>	40.0	Potassium,	<i>K.</i>	39.1
* Carbon,	<i>C.</i>	12.0	Rhodium,	<i>Rh.</i>	104.0
Cerium,	<i>Ce.</i>	91.3	Rubidium,	<i>Rb.</i>	85.4
Chlorine,	<i>Cl.</i>	35.5	Ruthenium,	<i>Ru.</i>	104.0
* Chromium,	<i>Cr.</i>	52.2	Samarium,	<i>Sm.</i>	150.0
Cobalt,	<i>Co.</i>	60.0	Scandium,	<i>Sc.</i>	44.9
* Columbium (Ni- obium, Nb.),	<i>Cb.</i>	94.0	* Selenium,	<i>Se.</i>	79.0
Copper,	<i>Cu.</i>	63.4	* Silicon,	<i>Si.</i>	28.0
Decipium,	<i>Dp.</i>	159.0	Silver,	<i>Ag.</i>	108.0
Didymium,	<i>D.</i>	95.0	Sodium,	<i>Na.</i>	23.0
Erbium,	<i>E.</i>	112.6	Strontium,	<i>Sr.</i>	88.0
<i>Fluorine,</i>	<i>F.</i>	19.0	* Sulphur,	<i>S.</i>	32.0
Gallium,	<i>Ga.</i>	69.8	* Tantalum,	<i>Ta.</i>	182.0
Glucium (Beryl- lium, Be.),	<i>Gl.</i>	9.2	* Tellurium,	<i>Te.</i>	128.0
* Gold,	<i>Au.</i>	197.0	Terbium,	<i>Tb.</i>	75.4
* Hydrogen,	<i>H.</i>	1.0	Thallium,	<i>Tl.</i>	204.0
Indium,	<i>In.</i>	113.4	Thorium,	<i>Th.</i>	118.4
<i>Iodine,</i>	<i>I.</i>	127.0	* Tin,	<i>Sn.</i>	118.0
Iridium,	<i>Ir.</i>	198.0	* Titanium,	<i>Ti.</i>	50.0
Iron,	<i>Fe.</i>	56.0	* Tungsten,	<i>W.</i>	184.0
Lanthanum,	<i>La.</i>	92.0	* Uranium,	<i>U.</i>	120.0
Lead,	<i>Pb.</i>	207.0	Vanadium,	<i>V.</i>	51.3
Lithium,	<i>Li.</i>	7.0	Ytterbium,	<i>Yb.</i>	173.0
Magnesium,	<i>Mg.</i>	24.0	Yttrium,	<i>Y.</i>	89.0
* Manganese,	<i>Mn.</i>	55.0	Zinc,	<i>Zn.</i>	65.0
			Zirconium,	<i>Zr.</i>	89.6

* Sometimes basic, sometimes acid.

NOTE.—Heavy-faced type indicates the elements of most importance to the student of this subject. Basic elements are printed in common type; acid elements in italics.

MISCELLANEOUS TABLES.

HEAT OF COMBUSTION OF VARIOUS SUBSTANCES.

Substance.	British Thermal Units (per Pound).
Hydrogen Gas (<i>H</i>)	62,000
Marsh-gas (<i>CH</i> ₄)	23,500
Carbonic Oxide Gas (<i>CO</i>)	4,300
Anthracite Coal	15,230
Bituminous Coal	14,400
Coke	12,600
Wood (ordinary)	5,000

RATES OF DIFFUSION OF GASES.

Gas.	Density, or Specific Gravity.	Square Root of Density.	$\frac{1}{\sqrt{\text{Density}}}$	Velocity of Diffusion. Air = 1.
Hydrogen	.0693	.2632	3.7987	3.830
Marsh-gas	.5590	.7477	1.3375	1.344
Carbonic Oxide	.9670	.9834	1.0169	1.015
Nitrogen	.9713	.9855	1.0147	1.014
Oxygen	1.1057	1.0515	.9510	.949
Sulphureted Hydro- gen	1.1912	1.0914	.9163	.950
Carbonic Acid	1.5291	1.2366	.8087	.812

EXPLOSIVES.

Explosive.	Temperature of the Explosion (F.).	Products of Explosion.		Ruptive Pressure. (Pounds per Sq. In.)
		Combustible.	Incombustible.	
Blasting Powder..	2,000° to 3,600°	42 per cent.	58 per cent.	12,400 to 20,500
Nitroglycerin.	5,740°	0 per cent.	100 per cent.	152,640
Dynamite	5,280°	0 per cent.	100 per cent.	48,000
Blasting-gelatine..	5,830°	46 per cent.	54 per cent.	.....
Gun-cotton	4,800°	61 per cent.	39 per cent.	90,000 to 100,000
Tonite	4,800°	8 per cent.	92 per cent.	.....
Roburite	3,800°	0 per cent.	100 per cent.	.....
Ammonite .....	.....	0 per cent.	100 per cent.	.....
Securite .....	.....	0 per cent.	100 per cent.	.....
Carbonite .....	.....	41 per cent.	59 per cent.	.....

ILLUMINATING POWER OF SAFETY-LAMPS.

Name of Lamp.	Illuminating Power of Lamp, with a Candle Taken as 1, or Unity.
Davy	.16
Geordy	.10
Clanny	.20
Mueseler	.35
Evan Thomas	.45
Marsaut, 3 gauzes	.45
Marsaut, 2 gauzes	.55
Howat's Deflector	.65
Ashworth-Hepplewhite-Gray	.65 (about)

TEMPERATURE OF COMBUSTION OF VARIOUS GASES.

Gases.	Temperature of Combustion (F.).
Marsh-Gas.	1,220°
Ordinary Illuminating Gas..	1,198°
Carbonic Oxide Gas.....	1,184°
Hydrogen.....	1,148°

HEAT, VOLUME OF GAS, AND EXPLOSIVE FORCE OF PROMINENT EXPLOSIVES.

Substance.	Heat.	Volume of Gas.	Estimated Explosive Force.
Blasting powder.....	510	0.173 liter*	88
Artillery powder.....	608	0.225 liter	137
Sporting powder.....	641	0.216 liter	139
Powder, nitrate of soda for its base	764	0.248 liter	190
Powder, chlorate of potash for its base.....	972	0.318 liter	309
Gun-cotton.....	590	0.801 liter	472
Picric acid	687	0.780 liter	536
Picrate of potash	578	0.585 liter	337
Gun-cotton, mixed with chlorate of potash	1,420	0.484 liter	680
Picric acid, mixed with chlorate of potash	1,424	0.408 liter	582
Picrate, mixed with chlorate of potash.....	1,420	0.337 liter	478
Nitroglycerin.....	1,320	0.710 liter	939

*A liter is equal to 61.027051 cubic inches.

COMBUSTION OF FUELS.

One Pound of Combustible.	Theoretical Weight of Gas, in Pounds, Required to Effect the Complete Combustion of One Pound of Combustible.		Actual Weight of Air, in Pounds, Required to Effect the Complete Combustion of One Pound of Combustible.		Total Heat of Combustion of One Pound of Combustible in B. T. U.	The Equivalent of the Total Heat of Combustion, Expressed in the Number of Pounds of Water under Atmospheric Pressure it Would Evaporate.	
	Oxygen.	Air.	With Chimney Draft and Initial Temperature of Air at 62° F.	With Blast Air-Supply at 62° F., and Waste Gases at 320° F.		6	7
	1	2	3	4	5		
Hydrogen	8.00	34.80	70	47	62,032	55.60	64.00
Carbon (completely burned)	2.66	11.60	22	15	14,500	13.00	15.00
Coal (of average composition)	2.46	10.70	21	14	14,133	12.67	14.63
Coke	2.50	10.90	22	15	13,550	12.14	14.02
Wood (average kiln-dried)	1.40	6.10	12	18	7,792	6.98	8.07
Petroleum	3.54	11.90	31	21	20,408	18.83	21.18

**HEATING SURFACE, GRATE AREA, AND
HORSEPOWER.**

Type of Boiler.	<u>Heating Surface</u> <u>Horsepower</u>	<u>Heating Surface</u> <u>Grate Area</u>
Plain Cylindrical	6 to 10	12 to 15
Flue.....	8 to 12	20 to 25
Return-Tubular.....	14 to 18	25 to 35
Vertical.. ..	15 to 20	25 to 30
Water-Tube	10 to 12	35 to 40
Locomotive.....	1 to 2	50 to 100

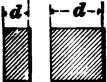
COEFFICIENTS OF FRICTION.

Description of Surfaces in Contact.	Disposition of Fibers.	State of the Surfaces.	Coefficient of Friction.
Oak on Oak	Parallel	Dry	.48
Oak on Oak	Parallel	Soaped	.16
Wrought Iron on Oak	Parallel	Dry	.62
Wrought Iron on Oak	Parallel	Soaped	.21
Cast Iron on Oak	Parallel	Dry	.49
Cast Iron on Oak	Parallel	Soaped	.19
Wrought Iron on Cast Iron .	—	Slightly Unctuous	.18
Wrought Iron on Bronze....	—	Slightly Unctuous	.18
Cast Iron on Cast Iron.....	—	Slightly Unctuous	.15

CONSTANTS USED IN DETERMINING M. E. P.

Cut-off.	Constant.	Cut-off.	Constant.	Cut-off.	Constant.
$\frac{1}{6}$	.566	$\frac{3}{8}$	.771	$\frac{2}{3}$	.917
$\frac{1}{5}$	.603	.4	.789	.7	.926
$\frac{1}{4}$	.659	$\frac{1}{2}$	.847	$\frac{3}{4}$	.937
.3	.708	.6	.895	.8	.944
$\frac{1}{3}$	.743	$\frac{5}{8}$	.904	$\frac{7}{8}$	.951

CONSTANTS FOR CAST-IRON PILLARS.

Cross-section of Pillar.	When Both Ends of the Pillar are Flat or Fixed.	When One End of the Pillar is Flat or Fixed, and the Other Round or Movable.	When Both Ends of the Pillar are Round or Movable.
 Round.	281.25	187.5	140.625
 Square or Rectangle.	375.00	250.0	187.500
 Thin Square Tube.	750.00	500.0	375.000
 Thin Round Tube.	562.50	375.0	281.250
 Angle with Equal Sides.	187.50	125.0	93.750
 Cross with Equal Arms.	187.50	125.0	93.750
 I Beam.	$375 \times \frac{A}{A+B}$	$250 \times \frac{A}{A+B}$	$125 \times \frac{A}{A+B}$

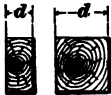
CONSTANTS FOR LINE SHAFTING.

Material of Shaft.	No Pulleys Between Bearings.	Pulleys Between Bearings.
Steel or Cold-Rolled Iron	65	85
Wrought Iron.....	70	95
Cast Iron.....	90	120

CONSTANTS FOR WROUGHT-IRON PILLARS.

Cross-section of Pillar.	When Both Ends of the Pillar are Flat or Fixed.	When One End of the Pillar is Flat or Fixed, and the Other Round or Movable.	When Both Ends of the Pillar are Round or Movable.
 Round.	2,250	1,500	1,125
 Square or Rectangle.	3,000	2,000	1,500
 Thin Square Tube.	6,000	4,000	3,000
 Thin Round Tube.	4,500	3,000	2,250
 Angle with Equal Sides.	1,500	1,000	750
 Cross with Equal Arms.	1,500	1,000	750
 I Beam	$3,000 \times \frac{A}{A+B}$	$2,000 \times \frac{A}{A+B}$	$1,500 \times \frac{A}{A+B}$

CONSTANTS FOR WOODEN PILLARS.

Cross-section of Pillar.	When Both Ends of the Pillar are Flat or Fixed.	When One End of the Pillar is Flat or Fixed, and the Other Round or Movable.	When Both Ends of the Pillar are Round or Movable.
 Round.	187.5	125.00	93.75
 Square or Rect-angle.	250.0	166.66	125.00
 Hollow Square Made of Boards.	500.0	333.33	250.00

CONSTANTS FOR TRANSVERSE STRENGTH OF BEAMS.

Materials.	Safe Transverse Strength in Pounds.	Materials.	Safe Transverse Strength in Pounds.
Metals:		Woods:	
Cast Iron.....	100	Birch.....	35
Wrought Iron...	150	Elm	25
Structural Steel	160	Ash.....	45
Copper.....	50	Beech.....	30
Brass.....	55	Hickory.	50
		Maple.....	60
		Oak (American)	45
		Pine (Pitch)...	40
		Pine (White)...	30

TENSILE STRENGTHS OF MATERIALS.

Materials.	Breaking Stress in Pounds per Square Inch.	Working Stress in Pounds per Square Inch.
Timber	10,000	600 to 1,200
Cast Iron	16,000	1,500 to 3,500
Wrought Iron	50,000	5,000 to 12,000
Steel	70,000	6,000 to 13,000

CRUSHING STRENGTHS OF MATERIALS.

Materials.	Crushing Strength in Tons per Square Inch.
Cast Iron.	40.0
Wrought Iron	18.0
Mild Steel	26.0
Cast Copper	5.0
Cast Brass.	4.5
Timber (dry).....	3.5
Brick	1.0
Stone	3.0

SHEARING STRENGTHS OF MATERIALS.

Materials.	Greatest Shearing Stress in Pounds per Square Inch.	Safe Shearing Stress in Pounds per Square Inch.
Cast Iron.	18,000	1,500 to 3,000
Wrought Iron	40,000	4,000 to 10,000
Steel	60,000	5,000 to 12,000

COMPOSITION OF FUELS.

	Carbon.	Hydrogen.	Oxygen.	*Disposable Hydrogen.
Wood (mean of several analyses).....	100	12.18	83.07	1.80
Peat.....	100	9.85	55.67	2.89
Lignite.....	100	8.37	42.42	3.07
Ten-yard seam of S. Staffordshire (Bituminous).....	100	6.12	21.23	3.47
Steam Coal.....	100	5.91	18.32	3.62
Anthracite.....	100	2.84	1.74	2.63

* Disposable Hydrogen is that portion of hydrogen available for heating purposes in fuel, which is in excess of the quantity required to form water with the oxygen contained in the coal.

SPACING OF LINE-SHAFT BEARINGS.

Diameter of Shaft in Inches.	Distance Between Bearings in Feet.	
	Wrought-Iron Shaft.	Steel Shaft.
2	11	11.50
3	13	13.75
4	15	15.75
5	17	18.25
6	19	20.00
7	21	22.25
8	23	24.00
9	25	26.00

TABLE FOR FINDING THE FIFTH ROOT OF A
NUMBER.

(Art. 1000.)

1	2	3	4	1	2	3	4
1.0	.100	.5000	1.0000	5.6	17.6	491.7	5,507.3
1.1	.133	.7321	1.6105	5.7	18.5	527.8	6,016.9
1.2	.173	1.037	2.4883	5.8	19.5	565.8	6,563.6
1.3	.220	1.428	3.7129	5.9	20.5	605.9	7,149.2
1.4	.274	1.921	5.3782	6.0	21.6	648.0	7,776.0
1.5	.338	2.531	7.5938	6.1	22.7	692.3	8,446.0
1.6	.410	3.277	10.486	6.2	23.8	738.8	9,161.3
1.7	.491	4.176	14.199	6.3	25.0	787.6	9,924.4
1.8	.583	5.249	18.896	6.4	26.2	838.9	10,737
1.9	.686	6.516	24.761	6.5	27.5	892.5	11,603
2.0	.800	8.000	32.000	6.6	28.7	948.7	12,523
2.1	.926	9.724	40.841	6.7	30.1	1,007	13,501
2.2	1.06	11.71	51.536	6.8	31.4	1,069	14,539
2.3	1.22	13.99	64.363	6.9	32.9	1,133	15,640
2.4	1.38	16.59	79.626	7.0	34.3	1,201	16,807
2.5	1.56	19.53	97.656	7.1	35.8	1,271	18,042
2.6	1.76	22.85	118.81	7.2	37.3	1,344	19,349
2.7	1.97	26.57	143.49	7.3	38.9	1,420	20,731
2.8	2.20	30.73	172.10	7.4	40.5	1,499	22,190
2.9	2.44	35.36	205.11	7.5	42.2	1,582	23,730
3.0	2.70	40.50	243.00	7.6	43.9	1,668	25,355
3.1	2.98	46.18	286.29	7.7	45.7	1,758	27,068
3.2	3.28	52.43	335.54	7.8	47.5	1,851	28,872
3.3	3.59	59.30	391.35	7.9	49.3	1,948	30,771
3.4	3.93	66.82	454.35	8.0	51.2	2,048	32,768
3.5	4.29	75.03	525.22	8.1	53.1	2,152	34,868
3.6	4.67	83.98	604.66	8.2	55.1	2,261	37,074
3.7	5.07	93.71	693.44	8.3	57.2	2,373	39,390
3.8	5.49	104.3	792.35	8.4	59.3	2,489	41,821
3.9	5.93	115.7	902.24	8.5	61.4	2,610	44,371
4.0	6.40	128.0	1,024.0	8.6	63.6	2,735	47,043
4.1	6.89	141.3	1,158.6	8.7	65.9	2,864	49,842
4.2	7.41	155.6	1,306.9	8.8	68.1	2,998	52,773
4.3	7.95	170.9	1,470.1	8.9	70.5	3,137	55,841
4.4	8.52	187.4	1,649.2	9.0	72.9	3,281	59,049
4.5	9.11	205.0	1,845.3	9.1	75.4	3,429	62,403
4.6	9.73	223.9	2,059.6	9.2	77.9	3,582	65,908
4.7	10.4	244.0	2,293.5	9.3	80.4	3,740	69,569
4.8	11.1	265.4	2,548.0	9.4	83.1	3,904	73,390
4.9	11.8	288.2	2,824.8	9.5	85.7	4,073	77,378
5.0	12.5	312.5	3,125.0	9.6	88.5	4,247	81,537
5.1	13.3	338.3	3,450.3	9.7	91.3	4,426	85,873
5.2	14.1	365.6	3,802.1	9.8	94.1	4,612	90,392
5.3	14.9	394.5	4,182.0	9.9	97.0	4,803	95,099
5.4	15.7	425.2	4,591.7	10.0	100.0	5,000	100,000
5.5	16.6	457.5	5,032.8				

**WEIGHT AND BREAKING STRENGTH OF IRON
AND STEEL WIRE ROPES.**

19 WIRES TO THE STRAND.

Diameter in Inches.	Weight in Lb. per Foot.	Breaking Load in Tons of 2,000 Lb.		
		Iron.	Cast Steel.	Plow Steel.
$\frac{1}{2}$	0.35	3.48	7.00	10.00
$\frac{9}{16}$	0.44	4.27	9.00	13.00
$\frac{5}{8}$	0.60	5.13	12.00	18.00
$\frac{3}{4}$	0.88	8.64	18.00	27.00
$\frac{7}{8}$	1.20	11.50	25.00	37.00
1	1.58	16.00	33.00	47.00
$1\frac{1}{8}$	2.00	20.00	42.00	60.00
$1\frac{1}{4}$	2.50	27.00	52.00	75.00
$1\frac{3}{8}$	3.00	33.00	63.00	90.00
$1\frac{1}{2}$	3.65	39.00	77.00	110.00
$1\frac{5}{8}$	4.10	44.00	86.00	123.00
$1\frac{3}{4}$	5.25	54.00	106.00	157.00
2	6.30	65.00	125.00	189.00

7 WIRES TO THE STRAND.

Diameter in Inches.	Weight in Lb. per Foot.	Breaking Load in Tons of 2,000 Lb.		
		Iron.	Cast Steel.	Plow Steel.
$\frac{1}{2}$	0.31	2.83	6.00	9.00
$\frac{9}{16}$	0.41	4.10	8.00	12.00
$\frac{5}{8}$	0.57	5.80	11.00	16.00
$\frac{11}{16}$	0.70	7.60	14.00	21.00
$\frac{3}{4}$	0.88	8.80	17.00	25.00
$\frac{7}{8}$	1.12	12.30	22.00	33.00
1	1.50	16.00	30.00	45.00
$1\frac{1}{8}$	1.82	20.00	36.00	
$1\frac{1}{4}$	2.28	25.00	44.00	
$1\frac{3}{8}$	2.77	30.00	52.00	
$1\frac{1}{2}$	3.37	36.00	62.00	

FLAT-STEEL ROPES.

Size. Inches.	Weight per Ft. Pounds.	Breaking Strength. Pounds.	Size. Inches.	Weight per Ft. Pounds.	Breaking Strength. Pounds.
$\frac{3}{8} \times 2$	1.27	38,500	$\frac{1}{2} \times 3$	2.57	76,500
$\frac{3}{8} \times 2\frac{1}{2}$	1.52	46,000	$\frac{1}{2} \times 3\frac{1}{2}$	3.00	89,500
$\frac{3}{8} \times 3$	2.02	61,000	$\frac{1}{2} \times 4$	3.43	102,000
$\frac{3}{8} \times 3\frac{1}{2}$	2.28	69,000	$\frac{1}{2} \times 4\frac{1}{2}$	3.86	115,000
$\frac{3}{8} \times 4$	2.53	76,500	$\frac{1}{2} \times 5$	4.29	127,500
$\frac{3}{8} \times 4\frac{1}{2}$	3.04	92,000	$\frac{1}{2} \times 6$	5.15	153,000
$\frac{3}{8} \times 5$	3.29	99,500	$\frac{1}{2} \times 7$	6.01	178,500
$\frac{3}{8} \times 6$	4.05	122,500	$\frac{1}{2} \times 8$	6.86	204,000
$\frac{5}{8} \times 4$	3.96	143,000	$\frac{3}{4} \times 5$	5.81	183,500
$\frac{5}{8} \times 4\frac{1}{2}$	4.62	166,500	$\frac{3}{4} \times 6$	7.74	245,000
$\frac{5}{8} \times 5$	5.28	190,500	$\frac{3}{4} \times 7$	8.71	275,500
$\frac{5}{8} \times 6$	6.60	238,000	$\frac{3}{4} \times 8$	9.68	306,000
$\frac{5}{8} \times 7$	7.26	262,000	$\frac{3}{4} \times 9$	11.62	367,000
$\frac{5}{8} \times 8$	8.58	309,500	$\frac{3}{4} \times 10$	12.58	398,000
$\frac{5}{8} \times 9$	9.24	333,000	$\frac{3}{4} \times 11$	13.55	428,500
$\frac{5}{8} \times 10$	10.56	381,000	$\frac{3}{4} \times 12$	15.49	489,500

RULES AND FORMULAS.

RULES USED IN TRIGONOMETRY.

THE TRIGONOMETRIC FUNCTIONS.

Art. 754.

Rule 1.— $\text{Sine} = \frac{\text{side opposite}}{\text{hypotenuse}}.$

Rule 2.— $\text{Side opposite} = \text{hypotenuse} \times \text{sine}.$

Rule 3.— $\text{Cosine} = \frac{\text{side adjacent}}{\text{hypotenuse}}.$

Rule 4.— $\text{Side adjacent} = \text{hypotenuse} \times \text{cosine}.$

Rule 5.— $\text{Tangent} = \frac{\text{side opposite}}{\text{side adjacent}}.$

Rule 6.— $\text{Side opposite} = \text{side adjacent} \times \text{tangent}.$

Rule 7.— $\text{Cotangent} = \frac{\text{side adjacent}}{\text{side opposite}}.$

Rule 8.— $\text{Side adjacent} = \text{cotangent} \times \text{side opposite}.$

Rule 9.— $\text{Hypotenuse} = \frac{\text{side opposite}}{\text{sine}}.$

Rule 10.— $\text{Hypotenuse} = \frac{\text{side adjacent}}{\text{cosine}}.$

RULES FOR USING TRIGONOMETRIC TABLES.

Given an angle, to find its sine, cosine, tangent, and cotangent:

Rule 11.—*Find in the table the sine, cosine, tangent, or cotangent corresponding to the degrees and minutes of the angle.*

For the seconds, find the difference of the values of the sine, cosine, tangent, or cotangent, taken from the table between which the seconds of the angle fall; multiply this difference by a fraction whose numerator is the number of seconds in the given angle, and whose denominator is 60.

If sine or tangent, add this correction to the value first found; if cosine or cotangent, subtract the correction. Art. 756.

To find the angle corresponding to a given sine, cosine, tangent, or cotangent, whose exact value is not contained in the table:

Rule 12.—*Find the difference of the two numbers in the table between which the given sine, cosine, or tangent falls, and use the number of parts in this difference as the denominator of a fraction.*

Find the difference between the number belonging to the smaller angle, and the given sine, cosine, tangent, or cotangent, and use the number of parts in the difference just found as the numerator of the fraction mentioned above. Multiply this fraction by 60, and the result will be the number of seconds to be added to the smaller angle. Art. 758.

RULES USED IN MENSURATION.

THE TRIANGLE.

Rule.—*The area of any triangle equals one-half the product of the base and the altitude.* Art. 766.

THE QUADRILATERAL.

To find the area of a parallelogram:

Rule.—*The area of any parallelogram equals the product of the base and the altitude.* Art. 777.

To find the area of a trapezoid:

Rule.—*The area of a trapezoid equals one-half the sum of the parallel sides multiplied by the altitude.* Art. 778.

To find the area of an irregular figure bounded by straight lines:

Rule.—*Divide the figure into triangles, and find the area of each triangle separately. The sum of the areas of all the triangles will be the area of the figure.* Art. 779.

THE CIRCLE.

To find the circumference or diameter of a circle:

Rule.—*The circumference of a circle equals the diameter multiplied by 3.1416.* Art. 780.

Rule.—*The diameter of a circle equals the circumference divided by 3.1416.* Art. 780.

To find the length of an arc of a circle :

Rule.—*The length of an arc of a circle equals the circumference of the circle of which the arc is a part, multiplied by the number of degrees in the arc, and divided by 360.* Art. 781.

To find the area of a circle:

Rule.—*Square the diameter, and multiply by .7854.* Art. 782.

Given the area of a circle, to find its diameter:

Rule.—*Divide the area by .7854 and extract the square root of the quotient.* Art. 783.

To find the area of a sector:

Rule.—*Divide the number of degrees in the arc of a sector by 360. Multiply the result by the area of the circle of which the sector is a part.* Art. 784.

To find the area of a segment of a circle:

Rule.—*Draw radii from the center of the circle to the extremities of the arc of the segment; find the area of the sector thus formed, subtract from this the area of the triangle formed by the radii and the chord of the arc of the segment, and the result is the area of the segment.* Art. 785.

THE ELLIPSE.

To find the perimeter of an ellipse: There is no exact method, but the following is close enough for most cases:

Rule.—*Multiply the major axis by 1.82, and the minor axis by 1.315. The sum of the results will be the perimeter.* Art. 788.

To find the exact area of an ellipse:

Rule.—*The area of an ellipse is equal to the product of its two diameters multiplied by .7854.* Art. 789.

ANY PLANE FIGURE.

Rule.—*The area of any plane figure may be found by dividing it into triangles, quadrilaterals, circles or parts of circles, and ellipses, finding the area of each part separately and adding them together.* Art. 790.

THE PRISM AND CYLINDER.

To find the area of the convex surface of any right prism, or right cylinder:

Rule.—*Multiply the perimeter of the base by the altitude.* Art. 803.

To find the volume of a right prism, or cylinder:

Rule.—*The volume of any right prism or cylinder equals the area of the base multiplied by the altitude.* Art. 804.

THE PYRAMID AND CONE.

To find the area of a right pyramid or right cone:

Rule.—*The convex area of a right pyramid or cone equals the perimeter of the base multiplied by one-half the slant height.* Art. 809.

To find the volume of a right pyramid or cone:

Rule.—*The volume of a right pyramid or cone equals the area of the base multiplied by one-third of the altitude.* Art. 810.

THE FRUSTUM OF A PYRAMID OR CONE.

To find the convex area of a frustum of a right pyramid or right cone:

Rule.—*The convex area of a frustum of a right pyramid or right cone equals one-half the sum of the perimeters of its bases multiplied by the slant height of the frustum.* Art. 814.

To find the volume of the frustum of a pyramid or cone:

Rule.—*Add the areas of the upper base, the lower base, and the square root of the product of the areas of the two bases; multiply this sum by one-third of the altitude.* Art. 815.

THE SPHERE.

To find the area of the surface of a sphere:

Rule.—*The area of the surface of a sphere equals the square of the diameter multiplied by 3.1416.* Art. 817.

To find the volume of a sphere:

Rule.—*The volume of a sphere equals the cube of the diameter multiplied by .5236.* Art. 818.

THE CYLINDRICAL RING.

To find the volume of a cylindrical ring:

Rule.—*Multiply the area of the cross-section of the ring by the length of the center line.* Art. 822.

FORMULAS USED IN GASES MET WITH IN MINES.

SPECIFIC GRAVITY.

Let W = weight of the substance in air;

W_1 = weight of the substance in water;

Sp. Gr. = specific gravity of the substance;

w = weight of one cubic foot of the substance.

$$\text{Then, Sp. Gr.} = \frac{W}{W - W_1}. \quad (1.) \text{ Art. 831.}$$

For solids or liquids,

$$\text{Sp. Gr.} = \frac{w}{62.5}. \quad (2.) \text{ Art. 831.}$$

$$w = 62.5 \times \text{Sp. Gr.} \quad (4.) \text{ Art. 832.}$$

For gases,

$$\text{Sp. Gr.} = \frac{w}{.0766}. \quad (3.) \text{ Art. 831.}$$

$$w = .0766 \times \text{Sp. Gr.} \quad (5.) \text{ Art. 832.}$$

**PRESSURE, VOLUME, DENSITY, AND WEIGHT OF AIR
WHEN THE TEMPERATURE IS CONSTANT.**

Mariotte's Law.—*The temperature remaining the same, the volume of a given quantity of gas varies inversely as the pressure.*

Let p = pressure for one position of the piston;
 p_1 = pressure for any other position of the piston;
 v = volume corresponding to the pressure p ;
 v_1 = volume corresponding to the pressure p_1 .

$$\left. \begin{array}{ll} \text{Then,} & p v = p_1 v_1; \quad (6.) \\ \text{also,} & p_1 = \frac{p v}{v_1}; \quad (7.) \\ \text{and,} & v_1 = \frac{p v}{p_1}. \quad (8.) \end{array} \right\} \text{Art. 852.}$$

Let D be the density corresponding to the pressure p and volume v , and D_1 be the density corresponding to the pressure p_1 and volume v_1 ; then,

$$\left. \begin{array}{l} p : D :: p_1 : D_1, \text{ or } p D_1 = p_1 D, \quad (9.) \\ \text{and } v : D_1 :: v_1 : D, \text{ or } v D = v_1 D_1. \quad (10.) \end{array} \right\} \text{Art. 852.}$$

Thus, let W be the weight of a quantity of air or other gas whose volume is v and pressure is p ; let W_1 be the weight of the same quantity when the volume is v_1 and pressure is p_1 ; then,

$$\left. \begin{array}{l} p : W :: p_1 : W_1, \text{ or } p W_1 = p_1 W. \quad (11.) \\ v : W_1 :: v_1 : W, \text{ or } v W = v_1 W_1. \quad (12.) \end{array} \right\} \text{Art. 852.}$$

**PRESSURE AND VOLUME OF A GAS WITH VARIABLE
TEMPERATURE.**

Gay-Lussac's Law.—*If the pressure remains constant, every increase of temperature of 1° F. produces in a given quantity of gas an expansion of $\frac{1}{481}$ of its volume at 32° F.*

If the pressure remains constant, it will also be found that every decrease of temperature of 1° F. will cause a decrease of $\frac{1}{481}$ of the volume at 32° F.

Let v = volume of gas before heating;

v_1 = volume of gas after heating;

t = temperature corresponding to volume v ;

t_1 = temperature corresponding to volume v_1 .

$$\text{Then, } v_1 = v \left(\frac{459 + t_1}{459 + t} \right). \quad (13.) \quad \text{Art. 854.}$$

Let p = the original tension;

t = the corresponding temperature;

t_1 = any higher or lower temperature;

p_1 = corresponding tension.

$$\text{Then, } p_1 = p \left(\frac{459 + t_1}{459 + t} \right). \quad (14.) \quad \text{Art. 854.}$$

Let P = pressure in pounds per square inch;

V = volume of air in cubic feet;

T = absolute temperature;

W = weight.

$$\text{Then, } P = \frac{.37052 \, W \, T}{V}. \quad (15.)$$

$$V = \frac{.37052 \, W \, T}{P}. \quad (16.)$$

$$T = \frac{P \, V}{.37052 \, W}. \quad (17.)$$

$$W = \frac{P \, V}{.37052 \, T}. \quad (18.)$$

} Art. 855.

MIXTURE OF TWO GASES HAVING UNEQUAL VOLUMES AND PRESSURES.

Let v and p be the volume and pressure, respectively, of one of the gases.

Let v_1 and p_1 be the volume and pressure, respectively, of the other gas.

Let V and P be the volume and pressure, respectively, of the mixture.

Then, if the temperature remains the same,

$$P = \frac{p \, v + p_1 \, v_1}{V}. \quad (19.)$$

$$V = \frac{p \, v + p_1 \, v_1}{P}. \quad (20.)$$

} Art. 857.

CALCULATION OF THE WEIGHT OF A GAS.

The weight of any gas, at a given pressure and temperature, is equal to the weight of an equal volume of air, at the same pressure and temperature, multiplied by the specific gravity of the gas.

Let W = weight in pounds;

V = volume in cubic feet;

B = barometric pressure in inches of mercury;

D = specific gravity of the gas—found in table of Rates of Diffusion of Gases;

T = absolute temperature.

$$\text{Then, } W = \frac{1.3253 \times V \times B \times D}{T}. \quad (21.) \text{ Art. 872.}$$

TO FIND THE WEIGHT OF A DYNAMITE CARTRIDGE.

Rule.—Multiply the square of the diameter of the cartridge by its length, all in inches, and take $\frac{1}{8}$ of the product; the result will be the weight of the cartridge in ounces.

Let W = weight of cartridge (ounces);

d = diameter of cartridge (inches);

l = length of cartridge (inches).

$$\text{Then, } W = \frac{1}{8} l d^2. \quad (22.) \text{ Art. 891.}$$

RULES AND FORMULAS USED IN MINE VENTILATION.**GRAVITATION.**

Law of Gravitation.—The force of attraction by which one body tends to draw another body towards it is directly proportional to its mass, and inversely proportional to the square of the distance between their centers. Art. 928.

Laws of Weight.—Bodies weigh most at the surface of the earth. Below the surface, the weight decreases as the distance to the center decreases.

Above the surface, the weight decreases as the square of the distance increases. Art. 929.

FORMULAS FOR GRAVITY PROBLEMS.

Let W = weight of body at the surface;

w = weight of a body at a given distance above or below the surface;

m = mass of the body;

d = distance between the center of the earth and the center of the body;

R = radius of the earth = 4,000 miles;

g = force of gravity where body is weighed.

$$\text{Mass} = \frac{\text{weight of body}}{\text{force of gravity}}, \text{ or } m = \frac{W}{g}. \quad (23.) \text{ Art. 927.}$$

Formula for weight when the body is below the surface:

$$wR = dW. \quad (24.) \text{ Art. 930.}$$

Formula for weight when the body is above the surface:

$$wd^2 = WR^2. \quad (25.) \text{ Art. 930.}$$

FORMULAS FOR FALLING BODIES.

Let g = force of gravity = constant accelerating force due to the attraction of the earth;

t = number of seconds the body falls;

v = velocity at the end of the time t ;

h = distance that a body falls during the time t .

$$v = gt. \quad (26.) \text{ Art. 933.}$$

That is, *the velocity acquired by a freely falling body at the end of t seconds equals 32.16 multiplied by the time in seconds.*

$$t = \frac{v}{g}. \quad (27.) \text{ Art. 933.}$$

That is, *the number of seconds during which a body must have fallen to acquire a given velocity equals the given velocity in feet per second divided by 32.16.*

$$h = \frac{v^2}{2g}. \quad (28.) \text{ Art. 933.}$$

That is, *the height from which a body must fall to acquire a given velocity equals the square of the given velocity divided by 2×32.16 .*

$$v = \sqrt{2gh}. \quad (29.) \text{ Art. 933.}$$

That is, *the velocity that a body will acquire in falling through a given height equals the square root of the product of twice 32.16, and the given height.*

$$h = \frac{1}{2}gt^2. \quad (30.) \text{ Art. 933.}$$

That is, *the distance a body will fall in a given time equals $32.16 \div 2$, multiplied by the square of the number of seconds.*

$$t = \sqrt{\frac{2h}{g}}. \quad (31.) \text{ Art. 933.}$$

That is, *the time it will take a body to fall through a given height equals the square root of twice the height divided by 32.16.*

THEORETICAL VELOCITY OF AIR.

Let v = velocity of air in feet per second;

F = the constant force represented by difference of
• pressure in pounds per square foot;

w = weight of a cubic foot of the air;

g = acceleration due to gravity = 32.16 ft.

Then,
$$v = \sqrt{\frac{2gF}{w}}. \quad (32.) \text{ Art. 940.}$$

THE MOTIVE COLUMN.

Let W = the weight of a cubic foot of air in the downcast shaft;

w = the weight of a cubic foot of air in the upcast shaft;

p = the pressure of the downcast shaft;

p_1 = the pressure in the upcast shaft;

t_1 = the average temperature of the air in the downcast shaft;

t = the average temperature of the air in the upcast shaft;

D = the depth of the upcast shaft in feet;

M = the length of the motive column in feet;

G = the water-gauge in inches.

$$\left. \begin{aligned} \text{Then, } M &= \frac{p - p_1}{W}. & (33.) \\ M &= \frac{5.2 G}{W}. & (34.) \\ M &= \frac{D(t - t_1)}{459 + t}. & (35.) \end{aligned} \right\} \text{Art. 942.}$$

THE THREE LAWS OF FRICTION.

As the result of many experiments, the truth of the three following laws, called the **three laws of friction**, has been firmly established.

First Law.—*When the velocity remains the same, the total pressure required to overcome friction varies directly as the extent of the rubbing surface.* Art. 946.

Second Law.—*When the velocities and rubbing surfaces remain the same, the pressures required to force air through the passages of a mine increase and decrease inversely as the sectional areas of the passages increase or decrease.* Art. 952.

Third Law.—*The pressure required to overcome friction in an airway varies as the squares of the velocities when the rubbing surface and the areas of section are the same; and the pressures required to overcome friction vary as the squares of the velocities multiplied by the rubbing surfaces per square foot of section in all airways.* Art. 955.

FORMULAS FOR VENTILATION.

Let a = sectional area of airway in square feet;

H = horsepower;

k = coefficient of friction = .0000000217;

l = length of airway in feet;

o = perimeter of airway in feet;
 p = ventilating pressure in pounds per square foot;
 P = total ventilating pressure in pounds;
 q = quantity of air in cubic feet per minute;
 s = rubbing surface in square feet;
 u = units of power in foot-pounds per minute;
 v = velocity in feet per minute;
 W = water-gauge in inches of water.

$$\begin{array}{ll}
 \text{Then, } P = p a. & (36.) \\
 P = k s v^3. & (37.) \\
 p = \frac{k s v^3}{a}. & (38.) \\
 s = \frac{P}{k v^3} = \frac{p a}{k v^3}. & (39.) \\
 v = \sqrt{\frac{p a}{k s}}. & (40.) \\
 l = \frac{s}{o}. & (41.) \\
 s = l o. & (42.)
 \end{array}
 \left. \vphantom{\begin{array}{l} (36.) \\ (37.) \\ (38.) \\ (39.) \\ (40.) \\ (41.) \\ (42.) \end{array}} \right\} \text{Art. 962.}$$

$$q = a v. \quad (43.) \quad \text{Art. 963.}$$

$$v = \frac{q}{a}. \quad (44.) \quad \text{Art. 965.}$$

$$a = \frac{q}{v}. \quad (45.) \quad \text{Art. 966.}$$

$$u = P v. \quad (46.) \quad \left. \vphantom{(46.)} \right\} \text{Art. 968.}$$

$$u = p q. \quad (47.) \quad \left. \vphantom{(47.)} \right\} \text{Art. 968.}$$

$$H = \frac{u}{33,000} = \frac{P v}{33,000} = \frac{p a v}{33,000} = \frac{p q}{33,000}. \quad (48.) \quad \text{Art. 968.}$$

$$\begin{array}{ll}
 p = \frac{33,000 H}{a v}. & (49.) \\
 p = \frac{33,000 H}{q}. & (50.)
 \end{array}
 \left. \vphantom{\begin{array}{l} (49.) \\ (50.) \end{array}} \right\} \text{Art. 969.}$$

$$\left. \begin{aligned} q &= \frac{33,000 H}{p}. & (51.) \\ v &= \frac{33,000 H}{P} = \frac{33,000 H}{p a}. & (52.) \end{aligned} \right\} \text{Art. 970.}$$

$$\left. \begin{aligned} u &= k s v^2. & (53.) \\ q &= \frac{k s v^2}{p}. & (54.) \end{aligned} \right\} \text{Art. 971.}$$

$$q = \sqrt{\frac{p d^2}{4 k l}}. \quad (55.) \quad \text{Art. 974.}$$

The above formulas, with others less important, are given below; they are so arranged that all the formulas used in obtaining the value of a given quantity are grouped together.

To find the area:

$$a = \frac{P}{p}.$$

$$a = \frac{k s v^2}{p}.$$

$$a = \frac{q}{v}.$$

$$a = \frac{u}{p v}.$$

$$a = \frac{33,000 H}{p v}.$$

$$a = \frac{k s v^2 q}{u}.$$

To find the horsepower:

$$H = \frac{u}{33,000}.$$

$$H = \frac{P v}{33,000}.$$

$$H = \frac{p q}{33,000}.$$

$$H = \frac{p a v}{33,000}.$$

To find the coefficient of friction:

$$k = \frac{P}{s v^3}.$$

$$k = \frac{p a}{s v^3}.$$

$$k = \frac{u}{s v^3}.$$

$$k = \frac{p q}{s v^3}.$$

To find the length of the airway:

$$l = \frac{s}{o}.$$

To find the perimeter of the airway:

$$o = \frac{s}{l}.$$

To find the total pressure:

$$P = p a.$$

$$P = k s v^3.$$

$$P = \frac{u}{v}.$$

$$P = \frac{33,000 H}{v}.$$

$$P = \frac{k s q^3}{a^3}.$$

To find the pressure in pounds per square foot:

$$p = \frac{P}{a}.$$

$$p = \frac{k s v^3}{a}.$$

$$p = \frac{u}{q}.$$

$$p = \frac{33,000 H}{a v}.$$

$$p = \frac{33,000 H}{q}.$$

$$p = \frac{k s v^3}{q}.$$

$$p = 5.2 W.$$

To find the quantity of air passing in cubic feet per minute.

$$q = a v.$$

$$q = \frac{u}{p}.$$

$$q = \frac{33,000 H}{p}.$$

$$q = \frac{k s v^3}{p}.$$

$$q = a \sqrt{\frac{p a}{k s}}.$$

To find the rubbing surface in square feet:

$$s = \frac{P}{k v^3}.$$

$$s = \frac{p a}{k v^3}.$$

$$s = l o.$$

$$s = \frac{u}{k v^3}.$$

$$s = \frac{p q}{k v^3}.$$

To find the units of power in foot-pounds per minute:

$$u = P v.$$

$$u = p q.$$

$$u = 33,000 H.$$

$$u = p a v.$$

$$u = k s v^3.$$

To find the velocity in feet per minute:

$$v = \sqrt{\frac{p a}{k s}}.$$

$$v = \sqrt{\frac{P}{k s}}.$$

$$v = \frac{q}{a}.$$

$$v = \frac{u}{P}.$$

$$v = \frac{u}{p a}.$$

$$v = \frac{33,000 H}{P}.$$

$$v = \frac{33,000 H}{p a}.$$

$$v = \sqrt[3]{\frac{u}{k s}}.$$

$$v = \sqrt[3]{\frac{p q}{k s}}.$$

To find the water-gauge:

$$W = \frac{p}{5.2}.$$

LAWS OF VENTILATION.

Art. 980.

In order to ascertain the effects produced by varying the airway, or by varying the quantity, velocity, etc., of the air, it is generally easier to make use of one of the following *laws* than to solve by means of one of the foregoing formulas. The laws are also useful for comparing the results obtained from two airways. Letting p , q , v , s , etc., represent, respectively, the pressure, quantity, velocity, rubbing surface, etc., before the change, and p_1 , q_1 , v_1 , s_1 , etc., the

same things after the change, the laws may be stated as follows:

(1) The pressure varies directly as the extent of the rubbing surface; i. e., $p : p_1 :: s : s_1$, or $P : P_1 :: s : s_1$.

(2) The pressure varies directly as the density* of the air; i. e., $p : p_1 :: w : w_1$, or $P : P_1 :: w : w_1$.

* By density is meant the *weight of a cubic foot in pounds*.

(3) The pressure varies directly as the square of the quantity; i. e., $p : p_1 :: q^2 : q_1^2$, or $P : P_1 :: q^2 : q_1^2$.

(4) The pressure varies directly as the square of the velocity; i. e., $p : p_1 :: v^2 : v_1^2$, or $P : P_1 :: v^2 : v_1^2$.

(5) The pressure varies directly as the length of the airway; i. e., $p : p_1 :: l : l_1$, or $P : P_1 :: l : l_1$.

(6) The pressure varies directly as the length of the perimeter; i. e., $p : p_1 :: o : o_1$, or $P : P_1 :: o : o_1$.

(7) The pressure per square foot varies inversely as the area of the airway; i. e., $p : p_1 :: a_1 : a$.

(8) The quantity varies directly as the square root of the pressure; i. e., $q : q_1 :: \sqrt{p} : \sqrt{p_1}$, or $q : q_1 :: \sqrt{P} : \sqrt{P_1}$.

(9) The quantity varies directly as the cube root of the power; i. e., $q : q_1 :: \sqrt[3]{u} : \sqrt[3]{u_1}$, or $q : q_1 :: \sqrt[3]{H} : \sqrt[3]{H_1}$.

(10) The quantity varies inversely as the square root of the rubbing surface; i. e., $q : q_1 :: \sqrt{s_1} : \sqrt{s}$.

(11) The velocity varies directly as the square root of the pressure; i. e., $v : v_1 :: \sqrt{p} : \sqrt{p_1}$, or $v : v_1 :: \sqrt{P} : \sqrt{P_1}$.

(12) The velocity varies directly as the square root of the area; i. e., $v : v_1 :: \sqrt{a} : \sqrt{a_1}$.

(13) The velocity varies inversely as the square root of the length of the airway; i. e., $v : v_1 :: \sqrt{l_1} : \sqrt{l}$.

(14) The velocity varies inversely as the square root of the rubbing surface; i. e., $v : v_1 :: \sqrt{s_1} : \sqrt{s}$.

(15) The power varies directly as the cube of the quantity; i. e., $u : u_1 :: q^3 : q_1^3$, or $H : H_1 :: q^3 : q_1^3$.

(16) The rubbing surface varies inversely as the square of the quantity; i. e., $s : s_1 :: q_1^2 : q^2$.

(17) The rubbing surface varies inversely as the square of the velocity; i. e., $s : s_1 :: v_1^2 : v^2$.

(18) The sectional area varies directly as the square of the velocity; i. e., $a : a_1 :: v^2 : v_1^2$.

(19) The length of the airway varies inversely as the square of the velocity; i. e., $l : l_1 :: v_1^2 : v^2$.

(20) The length of the airway varies inversely as the square of the quantity; i. e., $l : l_1 :: q_1^2 : q^2$.

For similar airways, let d equal the length of a side; then,

(21) The quantity varies directly as the square root of the fifth power of the length of the side; i. e., $q : q_1 :: \sqrt{d^5} : \sqrt{d_1^5}$.

(22) The pressure varies inversely as the fifth power of the length of the side; i. e., $p : p_1 :: d_1^5 : d^5$.

(23) The length of the side varies inversely as the fifth root of the pressure; i. e., $d : d_1 :: \sqrt[5]{p_1} : \sqrt[5]{p}$.

(24) The length of the side varies directly as the fifth root of the square of the quantity; i. e., $d : d_1 :: \sqrt[5]{q^2} : \sqrt[5]{q_1^2}$.

To the above laws may also be added another:

(25) If equal quantities of air pass through two airways, the velocities will vary inversely as the areas; i. e., $v : v_1 :: a_1 : a$.

AREA OF REGULATOR OPENING.

Let A = area of opening in square feet;

q = quantity of air in cubic feet per minute which it is desired to pass through the opening;

W = difference of pressure in inches of water on the two sides of the regulator.

$$\text{Then, } A = \frac{.0004 q}{\sqrt{W}}. \quad (56.) \text{ Art. 998.}$$

WEIGHT OF AIR.

Let W = weight of a cubic foot of air;
 B = height of barometer, inches of mercury;
 t = temperature of air, Fahrenheit.

$$W = \frac{1.3253 B}{459 + t}. \quad (57.) \text{ Art. 1006.}$$

EFFECT OF TEMPERATURE ON VOLUME OF AIR.

Let T = required absolute temperature;
 t = given temperature of air, Fahrenheit;
 V = volume of air at absolute temperature, T ;
 v = volume of air at Fahrenheit temperature, t .

$$T = \frac{V}{v} \times (459 + t). \quad (58.) \text{ Art. 1007.}$$

VENTILATING PRESSURE.

Let p = ventilating pressure in pounds per square foot;
 t = higher temperature of air;
 t_1 = lower temperature;
 D = depth of shaft.

$$p = \frac{(t - t_1)}{(459 + t)} \times .077 \times D. \quad (60.) \text{ Art. 1008.}$$

GRATE AREA OF VENTILATING FURNACE.

Let D = depth of furnace in feet;
 s = grate area per horsepower in square feet.

$$s = \frac{34}{\sqrt{D}}. \quad (61.) \text{ Art. 1010.}$$

RELATION BETWEEN WEIGHT OF AIR AND VENTILATING PRESSURE.

Let w = weight of one cubic foot of air in the upcast;
 W = weight of one cubic foot of air in the downcast;
 p = ventilating pressure in pounds per square foot;
 P = atmospheric pressure in pounds per square foot = 2,116.

$$w = \frac{P - p}{P} \times W. \quad (62.) \text{ Art. 1022.}$$

FLOW OF AIR.

Let v = velocity of air in feet per second;

p = difference of pressure producing the flow.

$$v = 18 \sqrt{p}. \quad (64.) \quad \text{Art. 1027.}$$

$$p = \left(\frac{v}{18}\right)^2. \quad (65.) \quad \text{Art. 1027.}$$

AREA OF AIR-PASSAGES.

Let d = diameter of port of entry in feet;

b = width of fan-blades in feet;

q = quantity of air in cubic feet passing through *one* port.

$$d = .0343 \sqrt{q}. \quad (66.) \quad \text{Art. 1030.}$$

$$b = \frac{1}{4} d. \quad (67.) \quad \text{Art. 1031.}$$

MANOMETRIC EFFICIENCY.

Let A = area of port of entry of fan;

a = area of port of discharge;

O = pressure required to blow air out of fan;

I = depression required for air to enter fan;

M = mine resistance in pounds per sq. ft. as measured with the water-gauge.

C = manometric efficiency.

$$O = \frac{A^2 I}{a^2}. \quad (68.) \quad \text{Art. 1032.}$$

$$C = \frac{100 M}{M + I + O}. \quad (69.) \quad \text{Art. 1032.}$$

CENTRIFUGAL FANS.**Centrifugal Force of a Body Moving in a Circle.**

Let w = weight of body in pounds;

v = velocity in feet per second;

R = radius of circle in feet;

$g = 32.16$ = acceleration due to gravity;

f = centrifugal force in pounds.

$$f = \frac{w v^2}{R g}. \quad (70.) \quad \text{Art. 1033.}$$

If the body is free to move outward, instead of being constrained to move in a circle, the formula becomes

$$f = \frac{wv^2}{3.1416g}. \quad (71.) \text{ Art. 1033.}$$

Centrifugal Force Developed by a Fan.

Let l = radial length of the fan-blade;

a = angle between blade and radius.

$$f = \frac{wl v^2}{3.1416g}. \quad (72.) \text{ Art. 1035.}$$

$$f = \frac{wl v^2 (\cos a)^2}{3.1416g}. \quad (75.) \text{ Art. 1037.}$$

Fan Dimensions.

Let D = diameter of fan;

d = diameter of port of entry;

r = radius of gyration of blade;

l = radial length of blade.

$$l = \frac{D - d}{2}. \quad (73.) \text{ Art. 1035.}$$

$$r = \frac{d}{2} + .6l. \quad (74.) \text{ Art. 1036.}$$

THERMOMETERS.

Let F = temperature in degrees Fahrenheit;

C = temperature in degrees Centigrade.

To change Centigrade readings to Fahrenheit:

$$F = \frac{9}{5}C + 32. \quad (76.) \text{ Art. 1067.}$$

To change Fahrenheit readings to Centigrade:

$$C = \frac{5}{9}(F - 32). \quad (77.) \text{ Art. 1067.}$$

FORMULAS USED IN MINE SURVEYING AND MAPPING.

TO FIND THE DISTANCE BETWEEN CHAMBERS OR ROOMS, MEASURED ALONG THE ENTRY.

Let D = required distance;

p = perpendicular distance between chambers;

A = angle between center lines of entry and chamber

$$D = \frac{p}{\sin A}. \quad (78.) \text{ Art. 1130.}$$

LATITUDES AND DEPARTURES.

Latitude = distance $\times$ cosine of bearing.
Departure = distance $\times$ sine of bearing. } Art. 1132.

CURVES.

Let R = radius of curve;
 D = deflection angle of curve;
 I = angle of intersection;
 T = tangent distance;
 c = chord;
 d = chord deflection;
 f = tangent deflection.

Then, $R = \frac{50}{\sin D}$. (79.) Art. 1200.

$T = R \tan \frac{1}{2} I$. (80.) Art. 1204.

$d = \frac{c^2}{R}$. (81.) Art. 1208.

$f = \frac{c^2}{2R}$. (82.) Art. 1208.

ECONOMIC GEOLOGY OF COAL.

**INCREASE OF TEMPERATURE WITH INCREASE OF DEPTH
BELOW THE EARTH'S SURFACE.**

Let T = temperature in degrees Fahrenheit;
 D = depth below surface in feet.

$T = 50.68 + \frac{D - 19.68}{67.2}$. (83.) Art. 1287.

**PROSPECTING FOR COAL AND LOCATION OF
OPENINGS.**

**THE ANGLE OF CORRECTED DIP FOR AN OBLIQUE
SECTION.**

Let a = tangent of angle of corrected dip;
 b = angle of dip at right angles to strike;
 c = angle at which the section lies to right or left of
the full dip.

Then, $a = \tan b \times \cos c$. (84.) Art. 1423.

The correction for the angles most used, as calculated
from the above formula, are given in the following table:

OBLIQUE SECTION TABLE.

$b =$		5°	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°
		Corrected Angles.											
$c = 5^{\circ}$	...	4° 59'	9° 58'	14° 57'	19° 56'	24° 55'	29° 50'	34° 54'	39° 51'	44° 53'	49° 54'	54° 54'	59° 54'
$c = 10^{\circ}$	...	4° 55'	9° 51'	14° 47'	19° 43'	24° 40'	29° 37'	34° 35'	39° 34'	44° 34'	49° 34'	54° 35'	59° 37'
$c = 15^{\circ}$	...	4° 50'	9° 40'	14° 31'	19° 22'	24° 15'	29° 09'	34° 04'	39° 02'	44° 00'	49° 01'	54° 04'	59° 08'
$c = 20^{\circ}$	...	4° 42'	9° 25'	14° 08'	18° 53'	23° 40'	28° 29'	33° 21'	38° 15'	43° 13'	48° 14'	53° 18'	58° 26'
$c = 25^{\circ}$	...	4° 32'	9° 05'	13° 39'	18° 15'	22° 54'	27° 37'	32° 24'	37° 15'	42° 11'	47° 12'	52° 19'	57° 04'
$c = 30^{\circ}$	$a =$	4° 20'	8° 41'	13° 04'	17° 30'	22° 00'	26° 34'	31° 14'	36° 00'	40° 54'	45° 54'	51° 03'	56° 18'
$c = 35^{\circ}$	...	4° 06'	8° 13'	12° 23'	16° 36'	20° 54'	25° 19'	29° 50'	34° 30'	39° 19'	44° 56'	50° 20'	54° 49'
$c = 40^{\circ}$	...	3° 50'	7° 42'	11° 36'	15° 35'	19° 39'	23° 51'	28° 16'	32° 44'	37° 27'	42° 25'	47° 34'	53° 00'
$c = 45^{\circ}$	...	3° 32'	7° 06'	10° 44'	14° 26'	18° 15'	22° 12'	26° 21'	30° 41'	35° 16'	40° 07'	45° 17'	50° 46'
$c = 50^{\circ}$	...	3° 13'	6° 28'	9° 47'	13° 10'	17° 28'	20° 22'	24° 14'	28° 20'	32° 44'	37° 27'	42° 33'	48° 05'
$c = 55^{\circ}$	...	2° 52'	5° 46'	8° 44'	11° 47'	14° 58'	18° 19'	21° 53'	25° 42'	29° 50'	34° 21'	39° 19'	44° 59'
$c = 60^{\circ}$	...	2° 30'	5° 02'	7° 38'	10° 19'	13° 07'	16° 06'	19° 17'	22° 45'	26° 34'	30° 27'	35° 32'	40° 54'

SHAFTS, SLOPES, AND DRIFTS.**TO FIND THE LENGTH OF THE WINDING COMPARTMENTS OF A RECTANGULAR SHAFT.**

Let S = output speed;
 D = depth of shaft;
 T = tonnage expressed in pounds;
 N = number of working hours;
 W = weight of a cubic foot of broken coal;
 B = average inside width of car;
 d = inside depth of car;
 L = length of compartment;
 f = clearance in shaft at ends of cage = 1 foot.

$$\text{Then, } L = \frac{TD}{SNWBd} + f. \quad (85.) \quad \text{Art. 1459.}$$

THICKNESS OF CAST-IRON TUBBING FOR CIRCULAR SHAFTS.

Let t = thickness of tubing in inches;
 d = diameter of shaft in feet;
 D = depth in feet;
 G = the crushing load of cast iron per square inch;
 usually taken at 90,000 pounds.

$$\text{Then, } t = \left\{ \frac{1}{\sqrt{1 - \frac{.868 D}{\frac{1}{8} G}}} - 1 \right\} \times 6d. \quad (86.) \quad \text{Art. 1480.}$$

The upper course of tubing should in all cases be at least $\frac{1}{2}$ an inch thick in the plate, even in shafts of very small diameter; and $\frac{5}{8}$ of an inch thick in shafts of large diameter, to prevent liability to fracture. It is also desirable to add a constant, usually $\frac{1}{8}$ of an inch, to the thickness obtained by the formula, to allow for wear and tear, and for corrosion or other chemical action on the metal.

In this formula no allowance is made for the extra strength given the segments by the flanges and ribs. Theoretically, each set of segments should have a different thickness, but in practice they are calculated for every 25 or 30 feet,

NUMBER OF BRICKS REQUIRED TO LINE A CIRCULAR SHAFT.

Let N = number of bricks required;
 D = outer diameter of the shaft;
 d = inner diameter of the shaft;
 t = thickness of brick;
 b = breadth of brick;
 l = length of brick;
 x = depth of shaft.

All dimensions must be in feet or all in inches.

$$N = \frac{.7854 x (D^2 - d^2)}{t b l}. \quad (87.) \text{ Art. 1487.}$$

METHODS OF WORKING COAL MINES.**RADIUS OF SHAFT PILLAR.**

Let R = required radius of pillar;
 D = depth of shaft;
 t = thickness of seam.

Then,
$$R = 3 \sqrt{D t}.$$

THICKNESS OF CYLINDRICAL OR SPHERICAL DAMS TO RESIST A GIVEN PRESSURE.

Let T = thickness in inches;
 R = short radius in inches;
 U = ultimate crushing strength in pounds per square inch, which is, for timber, 8,000; for stone, 6,000; and for brick, 2,500;
 P = head of water in pounds per square inch.

Then, for a cylindrical dam,

$$T = R \left\{ 1 - \sqrt{1 - \frac{20P}{U}} \right\}. \quad (88.) \text{ Art. 1710.}$$

For a spherical dam,

$$T = R \left\{ 1 - \sqrt[3]{1 - \frac{15P}{U}} \right\}. \quad (89.) \text{ Art. 1710.}$$

These formulas give very small thicknesses for dams to resist comparatively slight pressures. In no case, when a water head of over 10 feet is to be resisted, is it good practice to make the dam less than 3 feet thick. For heavy pressures the formulas are safe, provided their results exceed 36 inches, after being multiplied by 2.

FORMULAS USED IN MECHANICS.

MOTION AND VELOCITY.

Let s = distance traveled by moving body;

v = uniform velocity of body;

t = the time.

$$\text{Then, } v = \frac{s}{t}. \quad (90.) \text{ Art. 1827.}$$

$$s = v t. \quad (91.) \text{ Art. 1828.}$$

$$t = \frac{s}{v}. \quad (92.) \text{ Art. 1829.}$$

CENTER OF GRAVITY.

Let w = weight of smaller body;

W = weight of larger body;

l = distance between centers of gravity of the two bodies;

l_1 = distance from the center of gravity of the two to center of gravity of larger body.

$$\text{Then, } l_1 = \frac{w l}{W + w}. \quad (93.) \text{ Art. 1842.}$$

THE LEVER.

Let P = the power;

W = the weight;

a = perpendicular distance of power from fulcrum = power arm;

b = perpendicular distance of weight from fulcrum = weight arm;

$a_1, a_2, a_3, \dots$ = power arms of compound lever;

$b_1, b_2, b_3, \dots$ = weight arms of compound lever.

$$\text{Then, } P a = W b. \quad (94.) \text{ Art. 1851.}$$

$$P \times a_1 \times a_2 \times a_3 \times \dots = W \times b_1 \times b_2 \times b_3 \times \dots \quad (95.)$$

Art. 1852.

RELATION BETWEEN SPEED AND DIAMETER OF PULLEYS.

Let D = diameter of the driver;

d = diameter of the driven;

N = number of revolutions of the driver;

n = number of revolutions of the driven.

$$\text{Then, } D = \frac{dn}{N}. \quad (96.) \quad \text{Art. 1863.}$$

$$d = \frac{DN}{n}. \quad (97.) \quad \text{Art. 1864.}$$

$$n = \frac{DN}{d}. \quad (98.) \quad \text{Art. 1865.}$$

$$N = \frac{dn}{D}. \quad (99.) \quad \text{Art. 1866.}$$

WHEEL WORK.

Let $D_1, D_2, D_3, \dots$ = diameters of driving pulleys;

$d_1, d_2, d_3, \dots$ = diameters of driven pulleys;

P = power exerted;

W = weight lifted.

Then,

$$P = \frac{W \times d_1 \times d_2 \times d_3 \times \dots}{D_1 \times D_2 \times D_3 \times \dots} \quad (100.) \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Art. 1867.}$$

$$W = \frac{P \times D_1 \times D_2 \times D_3 \times \dots}{d_1 \times d_2 \times d_3 \times \dots} \quad (101.)$$

DIAMETER, PITCH, AND SPEED OF GEARS.

Let P = pitch;

T = number of teeth;

D = pitch diameter of the wheel;

$$\text{Then, } D = \frac{PT}{3.1416}. \quad (102.) \quad \text{Art. 1873.}$$

$$T = \frac{3.1416 D}{P}. \quad (103.) \quad \text{Art. 1874.}$$

$$P = \frac{3.1416 D}{T}. \quad (104.) \quad \text{Art. 1875.}$$

Let R = number of revolutions per minute of the driver;
 r = number of revolutions per minute of the driven;
 T = number of teeth in the driver;
 t = number of teeth in the driven.

$$\text{Then, } T = \frac{tr}{R}. \quad (105.) \text{ Art. 1878.}$$

$$t = \frac{TR}{r}. \quad (106.) \text{ Art. 1879.}$$

$$r = \frac{TR}{t}. \quad (107.) \text{ Art. 1880.}$$

$$R = \frac{tr}{T}. \quad (108.) \text{ Art. 1881.}$$

LAW OF COMBINATION OF PULLEYS.

In any combination of pulleys where one continuous rope is used, a load on the free end will balance a weight on the movable block as many times as great as itself as there are parts of the rope supporting the load—not counting the free end.

HORSEPOWER OF GEARS.

Let p = pitch of teeth of gear (breadth of face is $2\frac{1}{2}$ to $3p$);
 s = speed of point on pitch circle in feet per minute;
 H = horsepower transmitted by gear.

$$\text{Then, } H = .01 s p^3. \quad (109.) \text{ Art. 1882.}$$

THE INCLINED PLANE.

When the power acts parallel to the plane:

The power multiplied by the length of the inclined plane equals the weight multiplied by the height of the inclined plane. Art. 1885.

When the power acts parallel to the base:

The power multiplied by the base is equal to the weight multiplied by the height of the inclined plane. Art. 1885.

THE SCREW.

Let W = weight lifted by screw;
 P = force applied to handle;
 p = pitch of screw;
 R = radius of circle of force P .

$$\left. \begin{aligned} \text{Then, } W &= \frac{6.2832 PR}{p} & (110.) \\ P &= \frac{p W}{6.2832 R} & (111.) \end{aligned} \right\} \text{Art. 1888.}$$

LAWS OF FRICTION.**Art. 1892.**

- (1) *Friction is directly proportional to the perpendicular pressure between the two surfaces in contact.*
- (2) *Friction is independent of the extent of the surfaces in contact when the total perpendicular pressure remains the same.*
- (3) *Friction increases with the roughness of the surfaces.*
- (4) *Friction is greater between surfaces of the same material than between those of different materials.*
- (5) *Friction is greatest at the beginning of motion.*
- (6) *Friction is greater between soft bodies than between hard ones.*
- (7) *Rolling friction is less than sliding friction.*
- (8) *Friction is diminished by polishing or lubricating the surfaces.*

CENTRIFUGAL FORCE.

Let F = centrifugal force in pounds;
 W = weight of revolving body in pounds;
 R = radius in feet of circle described by center of gravity of revolving body;
 N = revolutions per minute of revolving body.

$$\text{Then, } F = .00034 W R N^2. \quad (112.) \quad \text{Art. 1898.}$$

WORK AND ENERGY.

The force (or resistance) multiplied by the distance through which it acts equals the work. If a weight be raised, the weight multiplied by the vertical height of the lift equals the work. Art. 1902.

One horsepower is 33,000 foot-pounds per minute; in other words, it is 33,000 pounds raised vertically one foot in one minute, or 1 pound raised vertically 33,000 feet in one minute, or any combination that will, when multiplied together, give 33,000 foot-pounds in one minute. Art. 1903.

Let W = weight of a body in pounds;
 v = velocity of body in feet per second;
 K = kinetic energy.

$$\text{Then, } K = \frac{Wv^2}{64.32}. \quad (113.) \text{ Art. 1904.}$$

BELTS.

Let D = diameter of one pulley;
 D_1 = diameter of other pulley;
 L = distance between shafts;
 B = length of *open* belt.

$$B = 3\frac{1}{4} \left(\frac{D + D_1}{2} \right) + 2L. \quad (114.) \text{ Art. 1908.}$$

Let W = width of single belt in inches;
 W_1 = width of double belt;
 H = horsepower to be transmitted;
 S = speed of belt in feet per minute.

$$\text{Then, } W = \frac{800H}{S}. \quad (115.) \text{ Art. 1909.}$$

$$H = \frac{WS}{800}. \quad (116.) \text{ Art. 1910.}$$

$$W_1 = \frac{2}{3} W. \quad (117.) \text{ Art. 1911.}$$

TENSILE STRENGTH OF MATERIALS.

Let W = safe load in pounds;

A = area of minimum cross-section;

S = working stress in pounds per square inch (see table of Tensile Strengths of Materials).

$$W = A S. \quad (118.) \quad \text{Art. 1934.}$$

$$A = \frac{W}{S}. \quad (119.) \quad \text{Art. 1935.}$$

$$S = \frac{W}{A}. \quad (120.) \quad \text{Art. 1936.}$$

Formulas for the Strength of Chains.

Let W = safe load in pounds;

D = diameter in inches of the iron from which the links are made.

For a stud-link chain,

$$W = 18,000 D^2. \quad (121.) \quad \text{Art. 1938.}$$

For a close-link chain,

$$W = 12,000 D^2. \quad (122.) \quad \text{Art. 1939.}$$

Formulas for the Strength of Hemp Ropes.

Let W = maximum working load in pounds;

C = circumference of rope in inches.

$$\text{Then, } W = 100 C^2. \quad (123.) \quad \text{Art. 1941.}$$

$$C = .1 \sqrt{W}. \quad (124.) \quad \text{Art. 1942.}$$

Formulas for the Strength of Wire Ropes.

Let W = maximum working load in pounds;

C = circumference of rope in inches.

$$W = 600 C^2. \quad (125.) \quad \text{Art. 1944.}$$

$$C = .0408 \sqrt{W}. \quad (126.) \quad \text{Art. 1945.}$$

The above formulas are also applicable when computing the safe strength of steel-wire rope by substituting the constant 1,000 for the constant 600, and .0316 for .0408.

CRUSHING STRENGTH OF MATERIALS.**Formula for the Strength of Pillars.**

The following formula is applicable to pillars commonly used in practice, the lengths of which are about from 10 to 40 times their least diameter, or, if rectangular, their least thickness as indicated by d :

Let C = crushing strength in tons per sq. in. (see table of Crushing Strengths of Materials);

S = sectional area in inches;

L = length in inches;

d = least thickness of rectangular pillar, or diameter of round pillar in inches;

W = breaking load in tons;

a = constant (see table of Constants for Pillars).

$$\text{Then, } W = \frac{CS}{1 + \frac{L^2}{a d^2}}. \quad (127.) \text{ Art. 1951.}$$

TRANSVERSE STRENGTH OF MATERIALS.**Strength of Beams.**

d = depth of beam in inches;

w = width of beam in inches;

d_1 = diameter of cylindrical beam in inches;

L = length between supports in feet

= distance between load and fixed end, in the case of cantilevers;

S = safe transverse strength (see table of Constants for Transverse Strength of Beams);

W = safe load in pounds.

Cantilevers. (Load at End.)

$$W = \frac{d^3 w S}{L}. \quad (128.) \text{ Art. 1954.}$$

$$W = \frac{.6 d_1^3 S}{L}. \quad (129.) \text{ Art. 1955.}$$

If the load is uniformly distributed, multiply the results obtained from formulas 128 and 129 by 2.

Beams Supported at the Ends.

$$W = \frac{4 d^2 w S}{L}. \quad (130.) \text{ Art. 1957.}$$

$$W = \frac{4 d_1^2 \times .6 S}{L}. \quad (131.) \text{ Art. 1958.}$$

If the load is uniformly distributed, multiply the results obtained by 2.

SHEARING STRENGTH OF MATERIALS.

a = area of cross-section in square inches;

S = safe shearing stress (see table of Shearing Strengths of Materials);

W = safe load in pounds.

$$W = a S. \quad (132.) \text{ Art. 1963.}$$

LINE SHAFTING.

D = diameter of shaft;

R = revolutions per minute;

H = horsepower transmitted;

C = constant (see table of Constants for Line Shafting).

$$H = \frac{D^3 R}{C}. \quad (133.) \text{ Art. 1966.}$$

$$R = \frac{C H}{D^3}. \quad (134.) \text{ Art. 1967.}$$

$$D = \sqrt[3]{\frac{C H}{R}}. \quad (135.) \text{ Art. 1968.}$$

FORMULAS USED IN STEAM AND STEAM-BOILERS.**SPECIFIC HEAT.**

W = weight of body in pounds;

t = temperature before heat is applied;

t_1 = temperature after heat is applied;

c = specific heat of body;

U = number of B. T. U. required to raise temperature of body from t to t_1 .

$$U = c W (t_1 - t). \quad (136.) \text{ Art. 1983.}$$

TEMPERATURE OF MIXTURES.

$w, w_1, w_2, \dots$ = weights of the several substances, respectively;

$c, c_1, c_2, \dots$ = specific heats of the substances, respectively;

$t, t_1, t_2, \dots$ = temperatures of the substances, respectively;

T = final temperature of mixture.

$$T = \frac{w c t + w_1 c_1 t_1 + w_2 c_2 t_2 + \dots}{w c + w_1 c_1 + w_2 c_2 + \dots}. \quad (137.) \text{ Art. 1987.}$$

PRESSURE AND TEMPERATURE OF STEAM.

Let t = temperature of steam;

p = gauge-pressure of steam.

$$\text{Then, } t = 199 + 14 \sqrt{p}. \quad (138.) \text{ Art. 1996.}$$

$$p = \left(\frac{t - 199}{14} \right)^2. \quad (139.) \text{ Art. 1997.}$$

TOTAL HEAT OF VAPORIZATION.

Let H = total heat of vaporization in B. T. U.;

t = temperature of steam.

$$\text{Then, } H = 1,081.4 + .305 t. \quad (140.) \text{ Art. 1999.}$$

SAFE WORKING PRESSURE OF BOILERS.

Let t = thickness of plate in inches;

d = diameter of shell in inches;

c = a constant;

p = safe working pressure.

$$\text{Then, } p = \frac{c t}{d}. \quad (141.) \text{ Art. 2032.}$$

The constants to be used in formula 141 are as follows :

Wrought-iron plate, single-riveted joint.....	10,224
Wrought-iron plate, double-riveted joint.....	13,152
Steel plate, single-riveted joint.....	16,608
Steel plate, double-riveted joint.....	20,688

CHIMNEYS.

Let A = area of chimney;
 H = horsepower of boiler;
 h = height of chimney.

$$\text{Then, } h = \left(\frac{H}{3.33 A - 2 \sqrt{A}} \right)^2. \quad (142.) \quad \text{Art. 2036.}$$

FORMULAS USED IN STEAM-ENGINES.**INDICATED HORSEPOWER.**

I. H. P. = indicated horsepower of engine;
 P = mean effective pressure (M. E. P.) in lb. per square inch;
 A = area of piston in square inches;
 L = length of stroke in feet;
 N = number of strokes per minute.

$$\text{I. H. P.} = \frac{P L A N}{33,000}. \quad (143.) \quad \text{Art. 2067.}$$

MEAN EFFECTIVE PRESSURE.

p = gauge-pressure;
 k = a constant corresponding to the apparent cut-off
 (see table of Constants Used in Determining
 M. E. P.);

M. E. P. = mean effective pressure.

$$\text{M. E. P.} = .9 [k(p + 14.7) - 17]. \quad (144.) \quad \text{Art. 2069.}$$

For a condensing engine, subtract the condenser pressure instead of 17.

MECHANICAL EFFICIENCY OF ENGINE.

I. H. P. = indicated horsepower, or total horsepower developed;
 N. H. P. = the net horsepower; that is, the horsepower remaining for the performance of useful work =
 I. H. P. - Friction H. P.;

E_m = mechanical efficiency of engine.

$$E_m = \frac{\text{N. H. P.}}{\text{I. H. P.}}. \quad (146.) \quad \text{Art. 2076.}$$

PISTON SPEED. l = length of stroke in inches; R = number of revolutions per minute; S = piston speed in feet per minute.

$$S = \frac{lR}{6}. \quad (145.) \text{ Art. 2071.}$$

FORMULAS USED IN AIR AND AIR COMPRESSION.**AREA UNDER ADIABATIC CURVE.** p = higher pressure; p_1 = lower pressure; v = volume corresponding to pressure p ; v_1 = volume corresponding to pressure p_1 ; A = area under curve.

$$\text{Then, } A = \frac{pv - p_1v_1}{.41}. \quad (147.) \text{ Art. 2114.}$$

CALCULATION OF THE SIZE OF AN AIR-COMPRESSOR.Let H = the number of horsepower the engine is to develop; D = diameter of cylinder in inches; r = ratio of length of stroke to diameter of cylinder; P = mean effective pressure per sq. in. on the piston; N = number of strokes per minute.

$$\text{Then, } D = 79.6 \sqrt[3]{\frac{H}{rPN}}. \quad (148.) \text{ Art. 2152.}$$

FORMULAS USED IN HYDROMECHANICS AND PUMPING.**LIQUID PRESSURE.** a = area of a submerged surface in square inches; d = distance in inches of center of gravity of surface from surface of liquid; w = weight of a cubic inch of the fluid in pounds; p = pressure on surface of liquid, pounds per sq. in.; P = total pressure on submerged surface in pounds.

$$P = a (dw + p). \quad (164.) \text{ Art. 2179.}$$

MEAN VELOCITY OF FLOW.

Let Q = the quantity in cubic feet which passes any section in 1 second;

A = the area of the section in square feet;

v = the mean velocity in feet per second.

Then, $Q = A v.$ (165.) Art. 2185.

$$v = \frac{Q}{A}. \quad (166.) \text{ Art. 2185.}$$

VELOCITY OF EFFLUX OF AN ORIFICE.

Let v = the velocity of efflux in feet per second;

h = the head in feet on the orifice considered;

h_1 = the head equivalent to a pressure p .

$$v = \sqrt{2gh}. \quad (167.) \text{ Art. 2186.}$$

$$h = \frac{v^2}{2g}. \quad (168.) \text{ Art. 2186.}$$

$h_1 = \frac{p}{.434}$, where h_1 is in feet, and p in pounds per square inch.

$h_1 = \frac{p}{62.5}$, where h_1 is in feet, and p in pounds per square foot.

$h + h_1$ = the *total head*.

$$v = \sqrt{2g(h_1 + h)}. \quad (169.) \text{ Art. 2187.}$$

$$\text{Range} = \sqrt{4hy}, \quad (170.) \text{ Art. 2188.}$$

where y is the vertical height of the orifice above the point where the water strikes.

If a is the area of a large orifice in the bottom of a small vessel whose area is A , the velocity is

$$v = \sqrt{\frac{2gh}{1 - \frac{a^2}{A^2}}}. \quad (171.) \text{ Art. 2189.}$$

Actual velocity of efflux from a small square-edged orifice:

$$v = .98 \sqrt{2gh}. \quad (172.) \text{ Art. 2190.}$$

Actual quantity discharged from a small square-edged orifice:

$$Q = .615 A v. \quad (173.) \quad \text{Art. 2191.}$$

THEORETICAL AND ACTUAL DISCHARGE.

Let Q = theoretical number of cubic feet discharged per second;

v_m = theoretical mean velocity through orifice in feet per second = $Q \div A$;

A = area of orifice in square feet;

h = theoretical head necessary to give a mean velocity v_m ;

Q_a = actual quantity discharged in cubic feet per second.

Then, for an orifice in a thin plate, or a square-edged orifice (the hole itself may be of any shape—triangular, square, circular, etc.—but the edges must not be rounded), the actual quantity discharged is

$$Q_a = .615 Q = .615 A v_m = .615 A \sqrt{2gh}. \quad (174.) \quad \text{Art. 2195.}$$

For a discharge through a short tube:

$$Q_a = .815 Q = .815 A v_m = .815 A \sqrt{2gh}. \quad (175.) \quad \text{Art. 2195.}$$

For a discharge through a mouthpiece:

$$Q_a = .97 Q = .97 A v_m = .97 A \sqrt{2gh}. \quad (176.) \quad \text{Art. 2195.}$$

For a discharge through the compound mouthpiece, the area of the orifice being taken as the area of the smallest section:

$$Q_a = 1.5526 Q = 1.5526 A v_m = 1.5526 A \sqrt{2gh}. \quad (177.) \quad \text{Art. 2195.}$$

In these four formulas it is taken for granted that there is a constant head.

FLOW OF WATER THROUGH WEIRS.

If d = the depth of the opening in feet, and b its breadth in feet, the area of the opening is $A = d \times b$, and the theoretical discharge is $Q = d \times b \times v_m = d b \times \frac{2}{3} \sqrt{2gh} = \frac{2}{3} b d \sqrt{2gd}$, the head for this case being taken as d .

The actual discharge is

$$Q_a = .615 Q = .615 \times \frac{2}{3} b d \sqrt{2 g d} = .41 b \sqrt{2 g d^3}. \quad (178.)$$

Art. 2198.

That is, *the actual discharge in cubic feet per second through a weir whose top is on a level with the upper surface of the water, is equal to .41 multiplied by the breadth of the weir, multiplied by the square root of 2g times the cube of the depth of the weir. All dimensions are to be taken in feet.*

To obtain the mean velocity v_m , divide the actual discharge by the area of the weir, or

$$v_m = \frac{Q_a}{A} = \frac{Q_a}{b d}. \quad (179.) \quad \text{Art. 2199.}$$

For a weir whose upper edge is below the level of the upper surface of the water, let h_1 be the depth in feet of the top of the weir below the surface of the water, and h the depth in feet of the bottom of the weir below the surface of the water. The actual discharge Q_a in cubic feet per second is

$$Q_a = .41 b \sqrt{2 g} (\sqrt{h^3} - \sqrt{h_1^3}). \quad (180.) \quad \text{Art. 2201.}$$

FLOW OF WATER IN PIPES.

The Mean Velocity of Discharge.

For straight cylindrical pipes of uniform diameter:

Let v_m = mean velocity of discharge in feet per second;

h = total head in feet = the vertical distance between the level of the water in the reservoir and the point of discharge;

l = length of pipe in feet;

d = diameter of pipe in inches;

f = coefficient of friction.

$$\text{Then, } v_m = 2.315 \sqrt{\frac{h d}{f l + \frac{1}{8} d}}. \quad (181.) \quad \text{Art. 2203.}$$

When the pipe is very long, compared with the diameter, the following formula may be used:

$$v_m = 2.315 \sqrt{\frac{h d}{f l}}. \quad (182.) \quad \text{Art. 2204.}$$

The Actual Head.

The actual head necessary to produce a certain velocity v_m may be calculated by the formula

$$h = \frac{f l v_m^2}{5.36 d} + .0233 v_m^2. \quad (183.) \quad \text{Art. 2205.}$$

The Quantity Discharged from Pipes.

Let d = the diameter of the pipe in inches; then the discharge Q in gallons per second is

$$Q = .0408 d^2 v_m. \quad (184.) \quad \text{Art. 2206.}$$

If the diameter of the pipe and the discharge are known, the mean velocity v_m is

$$v_m = \frac{24.51 Q}{d^2}. \quad (185.) \quad \text{Art. 2207.}$$

If the head, the length of the pipe, and the diameter of the pipe are given, to find the discharge use the formula

$$Q = .09445 d^2 \sqrt{\frac{h d}{f l + .125 d}}. \quad (186.) \quad \text{Art. 2208.}$$

To find the value of f , calculate v_m by formula 182, assuming that $f = .025$, and get the final value of f from the following table (Art. 2209):

$v_m =$	0.1	0.2	0.3	0.4	0.5	0.6
$f =$	.0686	.0527	.0457	.0415	.0387	.0365
$v_m =$	0.7	0.8	0.9	1	1 ¼	1 ½
$f =$	.0349	.0336	.0325	.0315	.0297	.0284
$v_m =$	2	3	4	6	8	12
$f =$	.0265	.0243	.023	.0214	.0205	.0193

POWER NECESSARY TO WORK A PUMP.

Rule.—*In all pumps, whether lifting, force, steam, single or double acting, or centrifugal, the number of foot-pounds of power needed to work the pump is equal to the weight of the water in pounds multiplied by the vertical distance in feet between the level of the water in the well, or source, and the point of discharge, plus the work necessary to overcome the friction and other resistances.* Art. 2219.

Rule.—*The work done in one stroke of a pump is equal to the weight of a volume of water equal to the volume displaced by the piston during the stroke, multiplied by the total vertical distance in feet through which the water is to be raised, plus the work necessary to overcome the resistances.* Art. 2220.

DUTY OF A PUMP.

The duty of any pump or pumping-engine is the number of pounds of water raised one foot high for each 100 pounds of coal burned in the boiler. Art. 2222.

G = number of gallons discharged per hour;

h = total vertical distance in feet between the level of the water in sump, or other source of supply, and the point of discharge;

W = weight in pounds of coal burned per hour;

D = duty in foot-pounds.

$$D = \frac{835.5 G h}{W}. \quad (187.) \quad \text{Art. 2223.}$$

BALANCING THE PUMP-RODS.

Let F = force causing acceleration = weight of pit-work — weight of water column — frictional resistances;

W = total weight to be accelerated = weight of pit-work + weight of water column;

g = 32.16, the acceleration due to gravity;

f = acceleration of pit-work in feet per second;

s = stroke of engine;

t = time occupied in making stroke.

$$\text{Then, } f = \frac{g F}{W}. \quad (188.) \text{ Art. 2248.}$$

$$t = \sqrt{\frac{2 s}{f}}. \quad (189.) \text{ Art. 2249.}$$

CALCULATIONS PERTAINING TO PUMPS.

Head and Pressure.

To find the pressure in pounds per square inch corresponding to any given head of water:

Rule.—*Multiply the head in feet by .434; the result is the pressure in pounds per square inch.* Art. 2289.

To find the head of water corresponding to a given pressure in pounds per square inch:

Rule.—*Multiply the given pressure in pounds per square inch by 2.304; the result is the head in feet.* Art. 2290.

Size of Plunger-Cylinder for Given Discharge.

Let G = number of gallons discharged per minute;

S = plunger speed in feet per minute;

d = diameter of cylinder in inches.

Then, the theoretic diameter is given by the formula

$$d = 4.95 \sqrt{\frac{G}{S}}. \quad \text{Art. 2291.}$$

Since there is always more or less slip of the water past the plungers, it is usual to add $\frac{1}{4}$ of the required number of gallons to the value given to G in the above formula to allow for this slip. Doing so, the formula becomes

$$d = 5.535 \sqrt{\frac{G}{S}}. \quad (190.) \text{ Art. 2291.}$$

The Discharge of a Pump.

Allowing for slip,

$$G = .03264 d^3 S. \quad (191.) \text{ Art. 2292.}$$

The theoretic discharge is

$$G = .0408 d^3 S.$$

Horsepower Required for a Given Discharge. H = horsepower, allowing for friction and slip; h = height through which water is lifted.

$$H = .00038 G h. \quad (192.) \text{ Art. 2293.}$$

To find the height through which a pump will raise water with a given horsepower:

$$h = \frac{H}{.00038 G}. \quad (193.) \text{ Art. 2294.}$$

To Find the Size of the Steam or Air Cylinder of a Pump.Let S = piston speed; D = diameter of cylinder in inches; r = ratio between the length of stroke and diameter of cylinder; l = length of stroke in feet; N = number of strokes per minute; H = horsepower; P = steam or air pressure per sq. in.

$$\text{Then, } D = 205 \sqrt{\frac{H}{PS}}. \quad (194.) \text{ Art. 2295.}$$

The diameter may also be found by formula 148,

$$D = 79.6 \sqrt[3]{\frac{H}{rPN}}.$$

Having obtained the diameter by either formula 194 or formula 148, the stroke can be found by multiplying the diameter by the value of the ratio r . In case formula 194 is used, the number of strokes can be found by dividing the piston speed by the length of the stroke in feet.

Sizes of Suction and Delivery Pipes.

The usual practice is to allow a velocity of 200 feet per minute in the suction-pipe and 400 feet per minute in the delivery-pipe.

Let d_1 = diameter of suction-pipe; d_2 = diameter of delivery-pipe.

$$\text{Then, } d_1 = .35 \sqrt{G}. \quad (195.) \text{ Art. 2296.}$$

$$d_2 = .25 \sqrt{G}. \quad (196.) \text{ Art. 2296.}$$

The pipes may be larger than the values calculated by the above formulas, particularly the suction-pipe, but it is not a good plan to make them any smaller. The larger the pipes are, the less the velocity, and, consequently, the less the frictional resistances.

FORMULAS USED IN MINE HAULAGE.

GRAVITY-PLANES.

Let W_1 = weight in pounds of descending loaded car;

W_2 = weight in pounds of ascending empty car;

W_3 = weight in pounds of hauling rope;

a = percentage of grade, expressed decimally;

F = available gravity force due to coal;

F_1 = total gravity force due to coal;

F_2 = total force required to overcome weight and friction of rope.

$$F_2 = a W_2 + \frac{W_3}{40}. \quad (197.) \text{ Art. 2326.}$$

$$F_1 = a (W_1 - W_2). \quad (198.) \text{ Art. 2327.}$$

$$F = a (W_1 - W_2) - \frac{W_1 + W_3}{40}. \quad (199.) \text{ Art. 2327.}$$

ENGINE-PLANES AND TAIL-ROPE SYSTEMS.

W = total weight of train in pounds;

W_1 = weight of train of empty cars;

w = weight of hauling rope in pounds;

w_1 = difference between weights of hauling rope and tail-rope;

a = percentage of grade, expressed decimally;

T = tension in main rope in pounds;

T_1 = tension in tail-rope;

H = horsepower required for haulage;

v = velocity of rope in feet per minute.

$$T = \frac{W + w}{40} + a (W + w). \quad (200.) \text{ Art. 2348.}$$

When a return rope is used,

$$T = \frac{W + w}{40} + a W. \quad (201.) \text{ Art. 2353.}$$

$$T_1 = \frac{W_1 + w}{40} + a W_1. \quad \text{Art. 2366.}$$

$$H = \frac{T v}{33,000}. \quad (202.) \text{ Art. 2353.}$$

If the haulage-roads have a fall towards the bottom of the shaft, the tension in the hauling rope of a tail-rope system is

$$T = \frac{W + w}{40} - a (W - w_1). \quad (204.) \text{ Art. 2370.}$$

$$T_1 = \frac{W_1 + w}{40} + a (W_1 - w_1). \quad (205.) \text{ Art. 2370.}$$

ENDLESS-ROPE HAULAGE.

Number of Cars and Distance Apart on Haulage-Band.

O = output of coal, tons per day;

o = weight of coal in tons carried by single car;

o_1 = weight of coal in cars attached to hauling band;

D = distance traveled by a point of the rope in one day;

d = distance in feet traveled by rope from return sheave to hoisting-shaft;

n = number of full cars on main rope band;

r = distance in feet between cars on band.

$$\text{Then, } o_1 = \frac{O d}{D}. \quad (206.) \text{ Art. 2405.}$$

$$n = \frac{O d}{D o}. \quad (207.) \text{ Art. 2405.}$$

$$r = \frac{d}{n}. \quad (208.) \text{ Art. 2405.}$$

Tension on Ropes and Horsepower.

W = weight of loaded cars on one side of rope band;

w_1 = weight of empty cars on ingoing side of rope band;

w = weight of rope band;

a = percentage of grade, expressed decimally;

T = tension in rope in pounds.

$$\text{Then, } T = \frac{W + w_1 + w}{40} + a (W - w_1). \quad (210.)$$

Art. 2412,

If the road has a fall towards the shaft, the grade is negative, and the formula becomes:

$$T = \frac{W + w_1 + w}{40} - a(W - w_1).$$

RULES AND FORMULAS USED IN HOISTING AND HOISTING APPLIANCES.

SIZE OF ENGINE-CYLINDER.

Rule.—To find the actual load on the engines, add to the net load 10% of the gross load. Art. 2473.

Rule.—To find the work required of the engines per revolution of the drum, multiply the actual load in pounds by the working circumference of the drum in feet. Art. 2474.

Let D = diameter of cylinder in inches;

w = work done per revolution in foot-pounds;

P = mean effective pressure in pounds per square inch;

r = stroke divided by diameter;

r_1 = ratio of gear to pinion in second-motion engine.

$$D = 1.97 \sqrt[3]{\frac{w}{Pr}}. \quad (211.) \quad \text{Art. 2475.}$$

For second-motion engine,

$$D = 1.97 \sqrt[3]{\frac{w}{Pr r_1}}. \quad (212.) \quad \text{Art. 2479.}$$

CONICAL DRUMS.

Let M = the weight of material;

C = the weight of cage and car;

R = the weight of rope;

D = large diameter of drum;

d = small diameter of drum.

$$D = \frac{d(M + 2C + 2R)}{M + 2C}. \quad (213.) \quad \text{Art. 2491.}$$

INDEX.

TABLES.	PAGE	RULES AND FORMULAS.	PAGE
Table of Natural Sines, Cosines, Tangents, and Cotangents	1-20	RULES USED IN TRIGONOMETRY.	
Traverse Tables	21-29	The Trigonometric Functions	50
Radii and Deflections of Curves	30	Rules for Using Trigonometric Tables	50
Specific Gravities and Weights per Cubic Foot	31	RULES USED IN MENSURATION.	
" Heat of Various Substances	33	The Triangle	51
Analyses of Coal	34	" Quadrilateral	51
Coking and Non-Coking Coals	35	" Circle	51
Chemical Elements	36	" Ellipse	52
Heat of Combustion of Various Substances	37	Area of any Plane Figure	52
Rates of Diffusion of Gases	37	The Prism and Cylinder	53
Explosives	38	" Pyramid and Cone	53
Illuminating Power of Safety-Lamps	38	" Frustum of a Pyramid or Cone	53
Temperature of Combustion of Various Gases	39	" Sphere	54
Heat, Volume of Gas, and Explosive Force of Prominent Explosives	39	" Cylindrical Ring	54
Combustion of Fuels	40	FORMULAS USED IN GASES MET WITH IN MINES.	
Heating Surface, Grate Area, and Horsepower of Boilers	41	Specific Gravity	54
Coefficients of Friction	41	Pressure, Volume, Density, and Weight of Air When the Temperature Is Constant	55
Constants Used in Determining M. E. P.	42	Pressure and Volume of a Gas with Variable Temperature	55
" for Cast-Iron Pillars	42	Mixture of Two Gases Having Unequal Volumes and Temperatures	56
" " Line Shafting	43	Calculation of the Weight of a Gas	57
" " Wrought-Iron Pillars	43	Weight of a Dynamite Cartridge	57
" " Wooden Pillars	44	RULES AND FORMULAS USED IN MINE VENTILATION.	
" " Transverse Strength of Beams	44	Gravitation	57
Tensile Strength of Materials	45	Formulas for Gravity Problems	58
Crushing Strength of Materials	45	" " Falling Bodies	58
Shearing Strength of Materials	45	Theoretical Velocity of Air	59
Composition of Fuels	46	The Motive Column	59
Spacing of Line-Shaft Bearings	46	" Laws of Friction	60
Table for Finding Fifth Root of Numbers	47	Formulas for Ventilation	60
Weight and Breaking Strength of Iron and Steel Wire Ropes	48	Laws of Ventilation	65

RULES AND FORMULAS USED IN MINE VENTILATION — <i>Continued.</i>		FORMULAS USED IN MECHANICS— <i>Continued.</i>	
	PAGE		PAGE
Area of Regulator Opening	67	Relation between Speed and Diameter of Pulleys	76
Weight of Air	68	Wheel Work	76
Effect of Temperature on Vol- ume of Air	68	Diameter, Pitch, and Speed of Gears	76
Ventilating Pressure	68	Law of Combination of Pulleys	77
Grate Area of Ventilating Fur- nace	68	Horsepower of Gears	77
Relation between Weight of Air and Ventilating Pressure	68	The Inclined Plane	77
Flow of Air	69	Laws of Friction	78
Area of Air Passages of Fan	69	Centrifugal Force	78
Manometric Efficiency of Fan	69	Work and Energy	79
Centrifugal Force of Body Mov- ing in Circle	69	Belts	79
“ “ Developed by Fan	70	Tensile Strength of Materials	80
Fan Dimensions	70	Strength of Chains	80
Thermometers	70	“ “ Hemp and Wire Ropes	80
FORMULAS USED IN MINE SUR- VEYING AND MAPPING.		Crushing Strength of Materials	81
Distance between Chambers or Rooms Measured along the Entry	70	Transverse Strength of Ma- terials	81
Latitudes and Departures	71	Shearing Strength of Materials	82
Curves	71	Line Shafting	82
ECONOMIC GEOLOGY OF COAL.		FORMULAS USED IN STEAM AND STEAM-BOILERS.	
Increase of Temperature below Earth's Surface	71	Specific Heat	82
PROSPECTING FOR COAL AND LO- CATION OF OPENINGS.		Temperature of Mixtures	83
Angle of Corrected Dip for an Oblique Section	71	Pressure and Temperature of Steam	83
Oblique Section Table	72	Total Heat of Vaporization	83
SHAFTS, SLOPES, AND DRIFTS.		Safe Working Pressure of Boilers Chimneys	83
Length of the Winding Compart- ment of a Rectangular Shaft	73	FORMULAS USED IN STEAM-EN- GINES.	
Thickness of Cast-Iron Tubbing for Circular Shafts	73	Indicated Horsepower	84
Number of Bricks Required to Line a Circular Shaft	74	Mean Effective Pressure	84
METHODS OF WORKING COAL MINES.		Mechanical Efficiency of Engine Piston Speed	84
Radius of Shaft Pillar	74	FORMULAS USED IN AIR AND AIR COMPRESSION.	
Thickness of Cylindrical or Spherical Dams	74	Area Under an Adiabatic Curve Calculation of the Size of an Air- Compressor	85
FORMULAS USED IN MECHANICS.		FORMULAS USED IN HYDROME- CHANICS AND PUMPING.	
Motion and Velocity	75	Liquid Pressure	85
Center of Gravity	75	Mean Velocity of Flow	86
The Lever	75	Velocity of Efflux from an Orifice Theoretical and Actual Dis- charge	86
		Flow of Water through Weirs	87
		“ “ “ in Pipes	88

FORMULAS USED IN HYDROMECHANICS AND PUMPING—*Continued.*

	PAGE
Power Necessary to Work a Pump	90
Duty of a Pump	90
Balancing of Pump-Rods	90
Calculations Pertaining to Pumps Head and Pressure	91
Size of Plunger-Cylinder for Given Discharge	91
Discharge of a Pump	91
Horsepower Required for Given Discharge	92
Size of Steam or Air Cylinder of Pump	92
" " Suction and Delivery Pipes	92

FORMULAS USED IN MINE HAULAGE.

	PAGE
Gravity-Planes	93
Engine-Planes and Tail-Rope Systems	93
Endless-Rope Haulage	94
Number of Cars and Distance apart on Haulage-Band	94
Tension on Ropes and Horsepower	94

RULES AND FORMULAS USED IN HOISTING AND HOISTING APPLIANCES.

Size of Engine-Cylinder	95
Conical Drums	95

